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Abundance and Size Distributions of Penaeus spp. Shrimps in the Northern and Northwestern Gulf of Mexico During the 1982 Closure Period.

By

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ABSTRACT

Analyses of shrimp populations in shallow coastal waters of the Gulf of Mexico from Alabama to Texas during the Texas Closure (May 26-July 14, 1982) were made based on a collection of 299 trawl samples. Shrimp were more abundant off Texas than in the other areas, and were more abundant between 10 and 20 fathoms than at other depths. Catch per unit effort data from our samples indicated shrimp were 25% more abundant during the 1981 Texas Closure than during the 1982 closure. However, the substantial variability among catches caused this difference to not be statistically significant.

Populations of brown shrimp were examined through length-frequency analyses. Mean lengths in each 5-fm depth zone showed the typical increases with increasing water depths. Previous-year-class shrimp composed the vast majority of the shallow water (to 30 fm) populations, and new-year-class shrimp accounted for a relatively small portion of these populations. New-year-class shrimp were not as abundant off Texas in 1982 as in 1981.

A suggested revision of the sampling strategy is included to aid in completing management goals in the future.

INTRODUCTION

The harvest of penaeid shrimps has been an important commercial interest in Louisiana and Texas for the past five decades (Klima and Baxter, 1981). White shrimp are most important off Louisiana where the average annual landing is about 20 million pounds (heads-off), and brown shrimp are most important off Texas where the average annual landing is between 25 and 30 million pounds (NMFS, 1961-1981). These 20-year averages do not show the year-to-year varibility in the catches that can be substantial and which causes hardships for the industry when substantial deviation occurs.

The shrimping industry is based on the annual life cycle of these penaeid shrimps. During the period when juvenile and subadult brown shrimp migrate from the bays into the neritic Gulf of Mexico they are most vulnerable to harvest since they are concentrated at the passes. The Texas Closure provides substantial protection for these small to medium size shrimp during this migratory season, and provides time for the shrimp to grow to a more profitable size. By sampling during the closure period, we may be able to forecast the forthcoming harvest, and thus prepare the industry for a lean or bountiful season and reduce potential hardship. It is important to assess the accuracy of our predictions so improvements can be made if and when necessary.

The immediate objectives of this report are to describe the relative abundance of shrimp over the closed areas, and to describe the size composition of shrimp in these areas. A third objective is to compare the abundances and sizes of shrimp from the 1982 Closure with those obtained during the 1981 Closure for the area off Texas.

METHODS

Definitions.

To simplify interpretation of results, stations were sorted into 5-fathom "depth zones". Depth zone 1 encompassed stations in 1 to 5 fathoms, depth zone 2 encompassed those in 6 to 10 fathoms, and so on through depth zone 9 which encompassed stations in 40 to 45 fathoms. Additional separation of stations was made for the Texas Area by dividing these depth zones into four "statistical subareas". Statistical subareas 18-21 have long been used for the Texas gulf coast by NOAA's Technical Information and Management Service to record shrimp landings (Klima, 1980).

The term "new-year-class shrimp" refers to young shrimp that are less than 1-year-old and have just migrated from the bays into the Gulf. These shrimp generally have mean total lengths of 80, 90, and 100 mm for May, June, and July of the closure period, respectively (Trent, 1967; Copeland, 1965). "Previous-year-class shrimp" are defined herein as those that have over-wintered in the shallow gulf and have mean total lengths from 125 and 180 mm during the same months. Given sufficient food and 30 to 45 days in the gulf, the new-year-class shrimp are expected to grow an additional 20 to 30 mm (Parrack, 1979).

Sampling.

Sites to be sampled were chosen at random based on latitude and longitude values. Their distribution among the nine depth zones in each of the three major sampling areas is given in Table 1, and their locations are shown in Figures 1, 2, and 3, for the Eastern, Western, and Texas Areas, respectively.

A sample consisted of the catch from a 40-ft semiballoon shrimp trawl towed for 15 to 30 minutes. All Penaeus shrimps were culled from the total catch and weighed. Catch per unit effort (CPUE), used as a measure of relative abundance, is in terms of pounds of shrimp (heads-on) caught per 40-ft net per 30 min. tow, or the equivalent after standardization. Standardization adjusted CPUE's for different net sizes and towing times. Up to 200 specimens of each species were sexed and measured from each sample. Total length was obtained by measuring in millimeters the distance from the tip of the rostrum to the tip of the telson.

Analyses and statistics.

Basic statistics such as ranges, means, and confidence limits were calculated using standard procedures (Sokal and Rohlf, 1969). Transformations were usually applied to CPUE's and to lengths before computations of means and confidence limits, analysis of variance (ANOVA), and Student-Newman-Keuls (SNK) tests. A logarithmic transformation was usually appropriate (Taylor, 1961).

RESULTS

Composition.

Brown shrimp were the most abundant of the three commercial species of shrimp caught in all three major sampling areas (Table 2). They accounted for 51% of the shrimp caught in the Eastern Area, 95% of those caught in the Western Area, and 87% of the shrimp caught off Texas. Pink shrimp were nearly as abundant as brown shrimp in the Eastern Area where they accounted for 46% of the shrimp catch. Pink shrimp accounted for only 3.5% of the catch in the Western Area, but accounted for nearly 12% of the catch off Texas. White shrimp accounted for 1 to 3% of the shrimp catch in all three areas.

Relative Abundance.

Eastern Area. Shrimp were not abundant in this major sampling area. CPUE's ranged from 0.0 lbs to only 13.4 lbs, with zero catches being recorded in six of nine depth zones (Table 3A). Based on $\log_{10}(X+1)$ transformed data, mean CPUE's for the depth zones ranged from 0.0 lbs in depth zone 6 where only two samples were collected, to 2.2 lbs in depth zone 3 where 15 samples were collected. The overall mean CPUE for the Eastern Area was only

1.5 lbs.

Differences in shrimp abundances found in depth zones 1-5 were tested for significance in a 1-way ANOVA using $\log_e$ (X+1) transformed data. No significant difference was detected among the mean CPUE's for these five depth zones (Table 3B). This is readily apparent in Figure 4A, which shows the similar means, and their 95% confidence limits.

Western Area. Shrimp were slightly more abundant in this major sampling area than in the Eastern Area. CPUE's ranged from 0.0 lbs to 18.8 lbs, with zero catches being found in 5 of the 9 depth zones (Table 4A). Based on square root transformed data, mean CPUE's for the depth zones ranged from 0.05 lbs in depth zone 1 where five samples were collected, to 3.8 lbs in depth zone 3 where 5 samples were collected. The overall mean CPUE for the Western Area was 2.5 lbs.

Relative abundances of shrimp found in all nine depth zones were tested in a 1-way ANOVA using square root transformed CPUE data. A significant difference was found among the means of these depth zones (Table 4B). A subsequent least significant range test (=Student-Newman-Keuls test) shows three groups of means which were significantly different from each other (Table 4C). The first group of means which were not significantly different is most important and included those from depth zones 3 through 9. These means were significantly greater than those from depth zones 1 and 2. The second group included, with the means of the first group, the mean from depth zone 2, but excluded those from depth zones 5 and 3. The third group included the mean from depth zone 1 with the second group, and excluded the mean for depth zone 6. These groupings are not readily apparent even in Figure 4B which shows the mean CPUE's with 95% confidence limits for the depth zones.

Texas Area. Shrimp were more abundant in this major sampling area than in the previously described areas. CPUE's ranged from

0.3 lbs to 102.9 lbs (Table 5A). Very few zero catches were recorded from this area. Based on $\log_e$ (X+1) transformed CPUE data, mean CPUE's ranged from 2.1 lbs for depth zone 7 where only four samples were collected, up to 16.8 lbs for depth zone 3 where 21 samples were collected. The overall mean CPUE for the Texas Area as 9.1 lbs, just over three times that of the adjacent Western Area.

Mean CPUE's for all nine depth zones were tested in a 1-way ANOVA using $\log_e$ (X+1) transformed CPUE data. A very significant difference was found among the means for these depth zones (Table 5B). A subsequent Student-Newman-Keuls test showed the means from depth zones 2, 3, and 4 were significantly greater than those from the other depth zones (Table 5C). It also showed the means for depth zones 2 and 3 were always grouped together, and were significantly greater than those of all the other depth zones. This is readily apparent in Figure 5, which shows the mean CPUE's and their 95% confidence limits for the nine depth zones.

<u>1981 vs. 1982 Texas Closures</u>. A comparison between the first (1981) and the second (1982) closures revealed several similarities and differences in the relative abundances of shrimp off Texas. The first similarity was between the overall means for the two closures. The overall mean CPUE for 1981 was 12.4 lbs while that for 1982 was 9.1 lbs, a 25% reduction from 1981 to 1982. This difference, however, was not significant when tested in a 2-way ANOVA (Table 6). Most of this variability was attributable to different size catches in each of the different depth zones (Figure 6). Very significant differences were found among the mean CPUE's for the nine depth zones during both closures. These differences were generally similar from year to year for individual depth zones, as indicated by a non-significant interaction term in the ANOVA (Table 6B). A Student-Newman-Keuls test showed the mean CPUE's for depth zones 3 and 4 in 1981 and 2 and 3 in 1982, were significantly

greater than the means for the other depth zones (Table 6C). The others were not significantly different from each other except for the mean of depth zone 7 in 1981 which was significantly lower.

The majority of the shrimping effort is expended in depth zones 2 through 5 (Klima and Patella, 1981), which was also the area where most of our sampling was concentrated for the two closures. The overall mean CPUE for depth zones 2-5 combined for 1982 was 9.3 lbs, or about 30% lower than the 13.3 lbs. for 1981. These two means were significantly different when tested in a 1-way ANOVA using $\log_e$-transformed data (Table 7). Separate testing of each depth zone showed significant differences between the 1981 and 1982 mean CPUE's for depth zones 4 and 5 but not for the others. Additional inspection of the CPUE data for 1981 and 1982 in these depth zones showed most of the important differences between the years were localized in statistical subareas 19 and 20 (Table 8 and Figure 7). The mean CPUE's for depth zones 4 and 5 of statistical subareas 19 and 20 were four to five times higher in 1981 than in 1982. The mean for depth zone 3 in statistical subarea 20, and for depth zone 5 in subarea 21 were twice as high in 1981 as in 1982. The opposite situation, higher mean CPUE's in 1982 than in 1981, appeared to be important only for depth zone 2 of subarea 20 where the confidence limits did not overlap.

Size Distributions.

An anlaysis of relationship between mean lengths and their associated variances for brown shrimp from each depth zone of each statistical subarea sampled during the 1982 Closure, showed that a log-transformation of the original shrimp measurments would be required for analyses using parametric statistics (Taylor, 1961). Variances tended to increase from shallow water (depth zones 1 and 2) out to middle depths (depth zones 4 and 5) after which the trend disappeared (Figure 8). Mean lengths also appeared to increase from shallow water out to deep water (depth zones 8 and 9) as is commonly known.

Eastern Area. The brown shrimp in this area ranged in length from 71 mm (depth zone 2) to 209 mm (depth zone 8). Mean lengths were about the same for depth zones 1-3, being 114, 109, and 116 mm respectively (Table 9). Increases in mean lengths were noted from depth zone 3 through depth zone 8 (no data for zones 6 and 7), but the few shrimp caught and measured produced large confidence intervals (95%) surrounding the means of these deeper zones (Figure 9).

Length-frequency distributions of brown shrimp in depth zones 1-3 show fairly typical populations of previous-year-class shrimp with only a very small number of new-year-class shrimp included (Figure 10). The shrimp in these depth zones appear to be larger than those found in similar depths zones off Texas during May and June in earlier years (Trent, 1967; Copeland, 1965; Matthews, 1981). The few shrimp collected in depth zones 5, 8 and 9 were much larger, and were typical of the previous-year-class and older shrimp (Table 9).

Pink shrimp were almost as abundant as brown shrimp in the collections from this area. Pink shrimp ranged from 79 to 200 mm in total lengths. Their mean lengths were not significantly higher than those for brown shrimp in depth zones 1 and 3, and were not significantly lower in depth zones 4 and 5 (Table 9). Length-frequency distributions showed that populations in depth zones 1-3 contained both new-year-class and previous-year-class individuals (Figure 11). The ratio of new-year-class shrimp to previous-year-class shrimp changed from about 50:50 in depth zone 2, to 5:95 in depth zone 4.

White shrimp were not abundant at the sites sampled. White shrimp are normally limited to depth zones 1 and 2. They ranged in total length from 149 to 192 mm, and averaged about 167 mm (Table 9). These values are typical of previous-year-class and older shrimp (Figure 12).

Western Area. Brown shrimp total lengths ranged from a 70-mm individual from depth zone 2, to a 228-mm individual from depth zone 8 (Table 10). Their mean lengths increased from depth zone 1 where it was only 85 mm, to depth zone 8 where it was 184 mm. Few brown shrimp were caught and measured in depth zone 1 which accounts for the large confidence interval surrounding the mean (Figure 13). Confidence intervals were modest where many shrimp were measure (depth zones 2-6).

The brown shrimp populations found in depth zones 2-5 were composed largely of previous-year-class and older shrimp (Figures 14 and 15). New-year-class brown shrimp accounted for only about 25% of the populations from depth zone 2-6. Populations in depth zones 7-9 were solely previous-year-class and older shrimp.

Pink shrimp were found only in depth zones 2, 3, and 4 of the Western Area, and they were scarce. Total lengths ranged from 108 to 198 mm, and averaged 142, 154, and 158 mm for depth zones 1-3, respectively (Table 10). Few of the shrimp in these depth zones were new-year-class shrimp; over 90% were previous-year-class or older (Figure 16).

Few white shrimp were collected from the Western Area, primarily because only one sample was collected in their major habitat area, i.e. depth zone 1. White shrimp ranged from 115 to 205 mm in total lengths, and they averaged 152, 174, and 168 mm for depth zones 1-3, respectively (Table 10). Data and length-frequency distributions showed typically previous-year-class or older shrimp in depth zones 2 and 3. Only a few new-year-class shrimp were found in depth zone 1 (Figure 12).

Texas Area. Brown shrimp from the collections made in waters off Texas ranged from 62 to 250 mm in total lengths, and thus represented new-year-class shrimp, previous-year-class shrimp, and several shrimp and two, and possibly more, years old. Mean total lengths for brown shrimp increased from 92 mm in depth zone 1, to 181 mm in depth zones 7 and 9 (Table 11). Confidence limits were rather wide in depth zones 1, 7, and 9 where few shrimp were caught

(Figure 17).

Length-frequency distributions for brown shrimp populations showed the occurrences of new-year-class, previous-year-class, and two-year-old shrimp in several of the nine depth zones studied. The proportion of new-year-clsss shrimp decreased as water depth increased. The population in depth zone 1 was almost entirely new-year-class individuals, while depth zone 9 had none (Figures 18 and 19). The proportion of new-year-class shrimp decreased rapidly to about 25% of the populations in depth zones 2, 3, and 4. The proportions decreased to 10% of the population in depth zone 5, and to 2% in depth zone 6. No new-year-class were found in deeper waters. Previous-year-class were not abundant in depth zones 2, 3, and 4, but they accounted for about 70% of these populations. Their proportions were reduced to 65% of the populations in depth zones 5 and 6, and to 10% in depth zones 7, 8, and 9. Older shrimp accounted for 90% of the populations in these last three depth zones.

Pink shrimp were collected mainly in depth zones 1-3, but a few were also collected in depth zones 4 and 5 (Table 11). Total lengths for pink shrimp ranged from 75 to 192 mm, but 98% of the shrimp were over 100 mm. Populations of pink shrimp in depth zones 1-4 were very similar (Figure 20). Only about 5% of these shrimp should be classified as new-year-class shrimp, and these were limited to populations in depth zones 1 and 2.

White shrimp were found only in depth zones 1 and 2 off Texas (Table 11). Total lengths ranged from 77 to 199 mm, and averaged 172 mm in depth zone 1 and 169 mm in depth zone 2. Only about 3% of these shrimp should be classified as new-year-class shrimp, the remainder being either previous-year-class or older (Figure 12). New-year-class white shrimp generally leave the bays in the fall, thus their rarity in these collections.

1981 vs. 1982 Texas Closure. Although brown shrimp populations during both years showed increasing mean lengths from shallow water depth zones to deeper water depth zones, the mean lengths were consistently greater in 1982 populations for each depth zone (Figure 21). Sometimes the differences were small, as in depth zone 4 where the 1981 and 1982 means were 110 and 111.2 mm, respectively, and depth zone 8 where they were 175.9 and 176.6 mm, respectively (Table 12). Differences were large in depth zone 6 where the 1981 and 1982 means were 124.4 and 164.3 mm, respectively, and in depth zone 7 where they were 136.5 and 181.1 mm, respectively. The large confidence intervals encompassing the means in depth zone 7, however, were a result of too few shrimp having been caught and measured, and as a result the difference between the means as not statistically significant. Only the differences between the 1981 and 1982 means for depth zones 2, 3, 5, and 6 were statistically significant. A comparison of length-frequency distributions for 1981 and 1982 brown shrimp populations in depth zones 1-6 revealed a much larger proportion of small, new-year-class shrimp in the 1981 populations in these depth zones (Figures 18, 19, 22 and 23).

When populations were examined by statistical subareas as well as by depth zones, they were not quite as uniform along the entire Texas coast as first supposed (Figure 24). Mean lengths from 1981 and 1982 populations for depth zones 2-5 were only significantly different in 8 of 16 cases when separately tested with 1-way ANOVA's by statistical subareas (Table 13), versus the 3 of 4 cases that were significant when tested with the four subareas combined. In two cases, depth zone 4 in subarea 20 and zone 5 in subarea 18, the 1981 mean lengths were greater than those of 1982. The differences in these two cases, however, were not statistically significant. These results suggest attention to statistical subareas is important in studies of shrimp populations and should be considered in arranging a sampling regime. Stronger contributions of new-year-class shrimp are somewhat localized along the Texas coast according to data from both 1981 and 1982 Closures.

DISCUSSION

During the 1982 closure period shrimp were more abundant off Texas than they were off Louisiana, Mississippi, or Alabama. The greatest differences were found in depth zones 2, 3, and 4, where shrimp were most abundant off Texas (Figure 25). Depth zones 3 and 4 off Texas were also among the most heavily worked zones when commercial shrimping resumed after the Texas Closure (Klima et al., 1982).

The greater catches in the Texas Area appear to be due to a greater abundance of new-year-class and previous-year-class brown shrimp. Depth zones 2-4 off Texas had many more shrimp than did similar zones in the Eastern and Western Areas. This is based on the similar mean lengths for brown shrimp in all three major areas (Figure 26). Mean lengths for depth zones 2 and 3 for Texas were insignificantly lower than those for the other areas, but the mean length for depth zone 4 off Texas was significantly lower than the other areas. This indicated a larger portion of new-year-class shrimp in the Texas waters. The abundance of smaller shrimp appears to be important in the autumn commercial landings.

The contributions of pink shrimp to the Eastern and the Texas Areas were substantial, but white shrimp contributed surprisingly little to any of the three major sampling areas. Mean lengths for pink shrimp in depth zones 2 and 3, zones which showed the greatest catches of pink shrimp, showed differences between the Eastern and Texas Areas. The Eastern Area means were lower than those for Texas and may well have been an influential factor causing lower CPUE's in the Eastern Area (Figure 27). White shrimp mean lengths for depth zone 1 were similar in the Eastern and Texas Areas, but were substantially lower for the Western Area which is well known for its shallow water white shrimp nursery areas. The hypoxic bottom waters found at several sites in the Western Area were undoubtedly indicators of adverse conditions for shrimp in that area

(Harper et al., 1981). These conditions may well have led to our low CPUE's for this area.

Populations of brown shrimp off Texas and out to 30 fathoms, were composed of larger shrimp in 1982 than in 1981 during the respective closure periods. It was the small, new-year-class shrimp that were very abundant during the 1981 Closure that reduced the mean lengths in 1981, and it was their great abundance that pushed the 1981 CPUE's slightly higher than those of 1982. The 1981 CPUE's were even more impressive when you realize collections were made mostly during June in 1981 and not until July in 1982. A month's time lapse in this season is sufficient for the 90 mm new-year-class shrimp which are typical of June, to grow to 100 mm new-year-class shrimp of July. If the same numbers of shrimp were present both years, we would expect CPUE's in 1982 to be significantly greater than those in 1981. Such differences were not found. Considering the importance of the new-year-class shrimp to the autumn harvest, we could expect a reduction in landings from those of 1981.

In comparing standing stocks of brown shrimp in depth zones 1-5 based on numbers of shrimp, the 1981 Texas waters had 34% more shrimp than the 1982 Texas waters during the closure period (Table 14). Numbers of shrimp were calculated using CPUE and length data obtained during sampling. Mean lengths for brown shrimp in each depth zone (1-5) in each statistical subarea (18-21) were used with Fontaine and Neal's (1971) length-weight conversion to obtain numbers per pound. Patella's (1975) work provided surface areas for each depth zone in each subarea. The assumptions of a 70% spread in the net mouth, and a 2-knot towing speed for each drag were used. It may well be the strength in numbers of the new-year-class that determine to a great extent the strength of the fall fishery.

Accurate estimation of shrimp abundances in various areas requires that a large number of samples be collected in each area when the variation among catches is great even over short distances. By splitting the study area into subareas, such as depth zones in statistical subareas, some of the variability in catches can be reduced, and thus, the number of samples required will be reduced. The 1981 and 1982 Closure sampling regimes for Texas were not designed with the solution of this problem in mind, and consequently the analyses were plagued with trying to distinguish features based on too few samples in some areas while there was a surplus in others. This could be remedied by allotting a specific number of samples--10 samples--to each depth zone in each statistical subarea.

An additional problem which became apparent in the comparison of the 1981 and 1982 Texas clsoures was that of different times (weeks and even months in this case) when samples were collected. Shrimp population structure changes within an annual cycle, and the weeks during the closure period are particularly dynamic ones for populations in the coastal shallow waters because new-year-class brown shrimp are being recruited from the bays. With this in mind, variability in catches can be somewhat reduced by confining the collection of samples to short terms such as one or two weeks. To meet one of the objectives of the Texas Closure, one which asks "how much of a benefit was this year's closure?", replicated sampling should be employed. Thus, instead of 10 samples per area collected sometime during the closure period, 5 samples should be taken in each depth zone of each statistical subarea during the first two weeks of the closure and again during the last two weeks of the closure. Then the growth of the shrimp populations could be assessed for additional poundages saved because of the closure's protection of small economically wasteful shrimp from harvest.

SUMMARY

1. Brown shrimp, Penaeus aztecus, accounted for about 78% of the shrimp collected during the 1982 Texas Closure sampling. Pink shrimp, P. duorarum, accounted for about 20%, and white shrimp, P. setiferus, accounted for about 2%.

2. Penaeus spp. shrimp were scarce in the Eastern and Western Areas during the 1982 Texas Closure. Average catches in these two areas were 1.5 and 2.5 lbs, respectively, for a 30-minute drag with a single 40-foot net (CPUE).

3. Differences in CPUE's were minor through all nine 5-fathom depth zones of both Eastern and Western Areas, but the differences in the mean CPUE's for the depth zones in the Western Area were statistically significant.

4. Shrimp were just over three times more abundant in the Texas Area than in the Western Area. The average CPUE was 9.1 lbs in the Texas Area. Very significantly larger mean CPUE's were found in depth zones 2 and 3, i.e. in 6 to 15 fathoms, than in other depth zones.

5. The mean CPUE for the Texas Area was 12.4 lbs during the 1981 Texas Closure which was 36% higher than that for the 1982 closure, however, a paired comparison test indicated this difference between the two means was not statistically significant due to the large variability in catches in several depth zones. Shrimp are notoriously patchy in their distributions as we have found with CPUE's among the various depth zones and statistical subareas.

6. In all three major sampling areas, brown shrimp mean lengths increased with increasing water depths, from mean total lengths

of about 90 mm in 5 fathoms, to means of about 180 mm in 45 fathoms.

7. Pink shrimp mean lengths were similar to those of brown shrimp caught at the same depths in the Eastern Area, but were about 10% greater than for borwns in the Western and Texas Areas.

8. White shrimp mean lengths were much larger than those of brown and pink shrimp caught in the same area. These white shrimp were obviously previous-year-class and older shrimp.

9. Mean total lengths for brown shrimp populations in each of the nine depth zones in the Texas Area (statistical subareas lumped) were consistently greater in 1982 than in 1981, and were significantly so for depth zones 2, 3, 5 and 6.

10. Substantial decreases in the abundance of new-year-class brown shrimp were noted between 1981 and 1982 Texas Closure collections based on the length-frequency distributions for depth zones 1-3 (=1 to 15 fathoms) along the Texas coast. Such decreases appear to have been sufficient to cause the lower CPUE's found in 1982, and will probably be reflected in lower commercial landings for the remainder of the 1982 autumn shrimping season.

11. The sampling regime for the 1982 Texas Closure for the Texas Area was weak compared with that of 1981. Results from both closures, however, point to the need to revise the sampling regime to give it more structure prior to the application of random sampling.

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Table 1. Distrubition of sampling effort among the nine 5-fathom depth zones in the three major areas studied during the 1982 Texas Closure, 26 May-14 July.

Eastern = Collection sites in waters off Alabama, Mississippi, and Louisiana east of the Mississippi River delta.
Western = Collection sites in waters off Louisiana and west of the Mississippi River delta.
Texas = Collection sites in waters off Texas.

Depth Zone	Depth Range	Numbers of Samples		
		Eastern	Western	Texas
1	1 - 5 fm	4	5	4
2	6 - 10	25	25	20
3	11 - 15	15	25	21
4	16 - 20	6	28	21
5	21 - 25	5	26	21
6	26 - 30	2	9	7
7	31 - 35	1	5	4
8	36 - 40	1	5	4
9	41 - 45	1	5	4
	Totals:	60	133	106

Table 2. Relative abundances of brown, pink and white shrimp in each depth zone of the three major sampling areas based on samples collected during the Texas Closure, May 26-July 14, 1982.

Depth Zone	Total No. Caught	Percentages Brown, Pink and White of Total: Brown Shrimp	Pink Shrimp	White Shrimp
		EASTERN AREA		
1	149	74.5%	19.5	6.0
2	1,314	53.8	42.6	3.6
3	562	53.6	46.4	0.0
4	158	12.0	88.0	0.0
5	36	8.3	86.1	5.6
6	-	-	-	-
7	-	-	-	-
8	8	100.0	0.0	0.0
9	10	100.0	0.0	0.0
Combined	2,237	51.0	46.4	2.6
		WESTERN AREA		
1	32	37.5	0.0	62.5
2	2,013	88.8	7.8	3.4
3	2,740	95.3	3.4	1.3
4	933	99.0	0.5	0.5
5	1,195	99.8	0.0	0.2
6	246	100.0	0.0	0.0
7	87	100.0	0.0	0.0
8	40	100.0	0.0	0.0
9	38	100.0	0.0	0.0
Combined	7,324	94.7	3.5	1.8
		TEXAS AREA		
1	204	17.2	68.1	14.7
2	4,865	74.4	22.1	3.5
3	4,947	90.0	10.0	0.0
4	3,265	98.8	1.2	0.0
5	1,326	99.8	0.2	0.0
6	108	100.0	0.0	0.0
7	35	100.0	0.0	0.0
8	80	100.0	0.0	0.0
9	51	100.0	0.0	0.0
Combined	14,882	86.9	11.8	1.3

Table 3. CPUE statistics and the results of a 1-way ANOVA, both computed from LOG_e (X+1) transformed data. Collection sites were in shallow waters of the Gulf of Mexico in the Eastern Area. CPUE's are in pounds caught per 40-ft net towed for 30 minutes.

A. Statistics.

		CPUE Statistics (lbs.)			
Depth Zones	Samples	Minimum	Maximum	Mean	95% Confidence Limits
1	4	0.0	13.4	1.3	0.0 - 6.8
2	25	0.0	9.0	1.4	0.8 - 2.2
3	15	0.3	6.6	2.2	1.5 - 3.1
4	6	0.0	3.5	1.1	0.2 - 2.5
5	5	0.0	3.5	0.7	0.0 - 2.1
6	2	0.0	0.0	0.0	- -
7	1	0.0	-	-	- -
8	1	2.2	-	-	- -
9	1	2.6	-	-	- -
Combined	60	0.0	13.4	1.5	

B. Results of the 1-way ANOVA.

Source of Variation	DF	SS	MS	F	Significance
Total	54	27.4170			
Depth Zones	4	1.9792	0.4948	0.9726	0.431 n.s.
Within DZ's	50	25.4377	0.5088		

Table 4. CPUE statistics and results of a 1-way ANOVA and of a least significant range test. CPUE data were from collection sites in the Western Area, and were square root transformed for the computations. CPUE's are in pounds caught per 40-ft net towed for 30 minutes.

A. Statistics.

		CPUE Statistics (lbs.)			
Depth Zones	Samples	Minimum	Maximum	Mean	95% Confidence Limits
1	5	0.0	1.3	0.05	0.0 - 0.5
2	25	0.0	18.8	1.2	0.4 - 2.4
3	25	0.0	14.6	3.8	2.5 - 5.4
4	28	0.0	9.9	2.4	1.5 - 3.5
5	26	0.3	12.6	3.6	2.4 - 5.2
6	9	0.0	6.9	3.1	1.2 - 6.0
7	5	1.7	5.8	3.2	2.0 - 4.6
8	5	0.2	3.8	2.0	0.8 - 3.8
9	5	0.3	7.6	2.0	0.5 - 4.7
Combined	133	0.0	18.8	1.3	

B. Results of the 1-way ANOVA.

Source of Variation	DF	SS	MS	F	Significance
Total	132	128.95			
Depth Zones	8	21.73	2.716	3.14	0.003**
Within DZ's	124	107.23	0.865		

** = very significant

C. Results of a Student-Newman-Keuls test.

Depth zones: 1 2 4 7 8 9 6 5 3

Mean CPUE's from depth zones underlined together are not significantly different from each other, but are significantly different from those in other underlined groups or single means.

Table 5. CPUE statistics and results of a 1-way ANOVA and of a least significant range test. CPUE data were from samples collected in the Texas Area, and were LOG_e (X+1) transformed for the computations. CPUE's are in pounds caught per 40-ft net towed for 30 minutes.

A. Statistics.

		CPUE Statistics (lbs.)			
Depth Zones	Samples	Minimum	Maximum	Mean	95% Confidence Limits
1	4	0.4	10.0	2.6	0.5 - 7.7
2	20	2.0	52.5	14.0	8.9 - 21.6
3	21	3.9	102.9	16.8	10.9 - 25.8
4	21	1.0	67.2	7.9	5.2 - 11.8
5	21	0.3	14.3	4.2	3.0 - 5.7
6	7	0.9	8.7	2.5	1.3 - 4.1
7	4	0.6	7.5	2.1	0.5 - 5.4
8	4	3.8	20.4	6.5	2.7 - 14.0
9	4	2.0	10.0	3.3	1.3 - 6.9
Combined	106	0.3	102.9	9.1	

B. Results of the 1-way ANOVA.

Source of Variation	DF	SS	MS	F	Significance
Total	105	102.56			
Depth Zones	8	37.73	4.72	7.05	0.000***
Within DZ's	97	64.83	0.67		

*** = very highly significant

C. Results of a Student-Newman-Keuls test.
Depth zones: 7 6 1 9 5 8 4 2 3

Mean CPUE's from depth zones underlined together are not significantly different from each other, but are significantly different from those in other underlined groups or singles.

Table 6. A comparison of relative abundances of shrimp based on collections made off Texas during the 1981 and 1982 Closures, late May through mid-July.

A. Statistics.

Depth zones	1981 No. Samples	1981 Mean CPUE	1982 No. Samples	1982 Mean CPUE
1	25	3.7	4	2.6
2	63	8.8	20	14.0
3	51	24.3	21	16.9
4	35	17.9	21	7.9
5	27	7.2	21	4.2
6	10	5.4	7	2.4
7	6	0.4	4	2.1
8	2	0.9	4	6.5
9	4	0.9	4	3.3
Combined	223	12.4	106	9.1

B. Results of a 2-way ANOVA on Log_{10}-transformed data.

Source of Variation	DF	SS	MS	F	Significance
Total	1	0.434	0.434	0.651	0.420 n.s.
Depth Zones	8	109.912	13.739	20.581	0.000***
Interaction	8	2.342	0.293	0.438	0.989 n.s.
Error	311	207.614	0.668		

*** = very highly significant

C. Results of a Student-Newman-Keuls test.

07 08 09 N7 N6 N1 N9 01 N5 06 N8 05 N4 02 N2 N3 04 03

0#'s = 1981 depth zones.
N#'s = 1982 depth zones.

Table 7. Analyses of variance testing the mean CPUE's for depth zones 2, 3, 4, and 5, and 2-5 combined for 1981 and 1982 Texas Closures. Data were $\log_e$-transformed to disassociate means and variances.

Source of Variation	DF	SS	MS	F	Significance
		Depth Zone 2			
Years	1	1.6996	1.6996	2.4203	0.12349 n.s.
Error	85	59.6908	0.7022		
		Depth Zone 3			
Years	1	2.6774	2.6774	3.9595	0.05035 n.s.
Error	73	49.3624	0.6762		
		Depth Zone 4			
Years	1	7.4041	7.4041	9.2951	0.00355**
Error	54	43.0146	0.7966		
		Depth Zone 5			
Years	1	2.5168	2.5168	5.0294	0.02978*
Error	46	23.0186	0.5004		
		Depth Zones 2-5 Combined			
Years	1	6.4756	6.4756	7.4223	0.00687**
Error	264	230.3266	0.8724		

n.s. = not significant
* = significant
** = very significant

Table 8. Shrimp CPUE statistics for each of nine 5-fm depth zones in statistical subareas 18-21 (Texas coast) based on samples collected during the 1981 and 1982 closure periods. Data were $\log_{10}(x+1)$ transformed.

Stat. Subareas:	18		19		20		21	
		95%		95%		95%		95%
Depth Zone	Mean	Confid. Limits	Mean	Confid. Limits	Mean	Confid. Limits	Mean	Confid. Limits
1 (1981)	ns		ns		5.3	2.8 -- 9.5	ns	
(1982)	0.4	ss	1.5	ss	3.6	ss	10.0	ss
2	9.3	1.8 -- 36.4	10.0	7.0 -- 14.2	9.3	6.4 -- 13.2	11.4	4.7 -- 26.1
	5.6	2.5 -- 11.4	18.7	-1.0 -- 100.0+	30.2	13.5 -- 66.2	15.7	5.7 -- 40.4
3	12.8	7.3 -- 21.7	19.0	8.8 -- 40.1	43.9	34.3 -- 56.0	34.1	24.8 -- 46.8
	9.2	5.5 -- 15.0	17.3	4.7 -- 57.0	17.8	6.1 -- 48.7	28.7	16.1 -- 100.0+
4	3.3	-1.0 -- 100.0+	14.1	4.8 -- 37.8	21.0	11.3 -- 38.2	25.5	16.9 -- 38.2
	7.0	0.7 -- 36.9	5.6	3.8 -- 8.1	5.0	0.6 -- 21.7	17.2	4.8 -- 55.3
5	3.7	0.5 -- 13.7	6.8	2.5 -- 16.3	7.1	4.1 -- 11.8	10.5	4.8 -- 21.8
	6.2	4.6 -- 8.3	0.6	ss	1.3	-0.4 -- 7.0	4.6	2.9 -- 7.2
6	2.9	1.2 -- 5.8	ns		5.3	2.4 -- 10.4	11.6	0.2 -- 100.0+
	1.9	0.7 -- 3.7	ns		ns		3.4	-0.3 -- 26.8
7	0.3	-0.3 -- 1.6	ns		0.1	ss	0.6	-1.0 -- 75.4
	3.2	-1.0 -- 100.0+	ns		ns		1.3	-1.0 -- 100.0+
8	0.9	-1.0 -- 100.0+	ns		ns		ns	
	9.2	-1.0 -- 100.0+	ns		5.2	ss	3.8	ss
9	4.8	ss	ns		0.8	ss	0.1	0.1 -- 0.1
	2.2	0.4 -- 6.1	2.0	ss	10.0	ss	ns	

ns = no sample taken
ss = single sample taken

Table 9. Length statistics for shrimp collected in shallow (1-45 fm) waters of the Gulf of Mexico in the Eastern Area during May and June, 1982.

Depth Zone	# of Samples	# Shrimp Measured	Mean Length (mm)	19% Confidence Limits (mm)
		Brown Shrimp		
1	4	111	114	85 - 153
2	24	625	109	96 - 124
3	16	289	116	97 - 138
4	5	19	142	91 - 222
5	3	3	162	52 - 507
6	2	nc	-	- -
7	1	nc	-	- -
8	1	8	189	69 - 520
9	1	10	180	87 - 371
		Pink Shrimp		
1	4	23	123	67 - 225
2	24	538	109	95 - 125
3	16	253	122	103 - 145
4	5	139	137	115 - 163
5	3	31	155	134 - 181
		White Shrimp		
1	4	9	169	98 - 290
2	24	47	168	140 - 199
3	16	nc	-	- -
4	5	nc	-	- -
5	3	2	174	0 - 500+

nd = no data
nc = no catch

Table 10. Length statistics for shrimp caught in depth zones 1-9 of the Western Area sampled during June, 1982.

Depth Zone	# of Samples	# Shrimp Measured	Mean Length (mm)	95% Confidence Limits (mm)
			Brown Shrimp	
1	1	11	85	19 - 372
2	21	1700	116	108 - 125
3	25	2566	118	111 - 125
4	25	924	136	127 - 146
5	26	1193	139	132 - 147
6	6	246	150	139 - 163
7	5	87	168	147 - 192
8	5	40	184	132 - 256
9	5	38	174	133 - 230
			Pink Shrimp	
1	1	nc	-	- -
2	21	157	142	124 - 164
3	25	91	154	139 - 171
4	25	5	158	117 - 213
			White Shrimp	
1	1	20	152	115 - 201
2	21	68	174	143 - 212
3	25	35	168	135 - 209
4	25	4	168	52 - 500+
5	26	2	135	0 - 500+

nc = no catch

Table 11. Length statistics for shrimp caught in depth zones 1-9 off the Texas coast sampled during the first half of July, 1982.

Depth Zone	# of Samples	# Shrimp Measured	Mean Length (mm)	95% Confidence Limits (mm)
		Brown Shrimp		
1	4	35	92	46 - 182
2	24	3571	108	102 - 114
3	23	4445	114	108 - 119
4	24	3212	111	105 - 118
5	19	1323	142	135 - 149
6	8	108	164	150 - 181
7	4	35	181	129 - 254
8	4	80	177	145 - 215
9	4	52	181	137 - 239
		Pink Shrimp		
1	4	127	140	119 - 166
2	24	1059	135	126 - 144
3	23	481	137	125 - 151
4	24	38	138	98 - 193
5	19	3	127	3 - 500+
		White Shrimp		
1	4	30	172	129 - 228
2	24	169	169	153 - 187

Table 12. Comparisons between brown shrimp mean lengths from depth zones 1-9 for the 1981 and 1982 Texas Closures. Significance levels represent the results of 1-way ANOVA's between 1981 and 1982 samples in each depth zone.

Year	Depth Zone	No. of Samples	Mean Length (mm)	Significance	95% Condifence Limits (mm)
1981	1	24	80.5		70.8 - 91.4
1982		4	91.8	n.s.	46.3 - 181.9
1981	2	66	95.2	p<.001	91.1 - 99.6
1982		24	107.8	***	102.0 - 113.8
1981	3	53	107.5	p<.001	104.2 - 110.9
1982		23	114.0	***	108.9 - 119.3
1981	4	35	110.0		105.4 - 115.0
1982		20	111.2	n.s.	105.2 - 117.5
1981	5	28	120.2	p<.01	114.8 - 125.9
1982		19	141.8	**	135.0 - 148.9
1981	6	10	124.4	p<.05	112.8 - 137.2
1982		9	164.3	*	149.6 - 180.6
1981	7	5	136.5		97.5 - 191.1
1982		4	181.1	n.s.	129.0 - 254.4
1981	8	1	175.9		122.3 - 253.0
1982		4	176.6	n.s.	144.9 - 215.2
1981	9	4	163.2		145.7 - 182.8
1982		3	181.1	n.s.	137.3 - 239.0

Table 13. Comparisons between 1981 and 1982 mean lengths of brown shrimp collected from depth zones in statistical subareas 18-21 (=Texas Area) during the periods of the Texas closures.

Depth Zones	# of Samples 1981	# of Samples 1982	# of Shrimp Measured 1981	# of Shrimp Measured 1982	Mean Lengths 1981	Mean Lengths 1982	ANOVA Results F	ANOVA Results Significance
				Statistical Subarea 18				
1	0	1	----	8	----	101.5	----	----
2	5	12	560	1399	110.9	113.4	0.285	n.s.
3	15	7	2269	651	117.2	133.3	30.197	p<0.001
4	2	3	202	379	119.9	134.6	7.764	n.s.
5	12	7	849	617	150.5	147.0	0.284	n.s.
6	3	4	116	49	169.7	176.5	0.981	n.s.
7	2	2	8	24	184.9	185.1	0.000	n.s.
8	1	2	25	58	175.9	181.6	----	----
9	1	2	49	12	166.2	199.7	----	----
				Statistical Subarea 19				
1	0	1	----	2	----	86.0	----	----
2	15	2	1726	374	100.1	110.5	9.063	p<0.01
3	6	6	1173	1438	105.3	115.8	3.216	n.s.
4	9	8	1412	796	103.9	122.2	11.865	p<0.01
5	4	2	517	45	127.0	139.2	1.018	n.s.
				Statistical Subarea 20				
1	20	1	1112	16	80.4	96.2	----	----
2	44	5	2783	1524	90.6	111.4	7.649	p<0.01
3	24	4	5550	786	107.2	120.5	16.685	p<0.01
4	11	4	1487	537	114.9	109.7	0.505	n.s.
5	11	2	1507	37	120.1	139.5	2.005	n.s.
6	4	1	349	3	131.4	128.3	----	----
7	1	0	1	----	146.0	----	----	----
8	0	1	----	15	----	165.8	----	----
9	1	1	8	34	168.3	179.3	----	----
				Statistical Subarea 21				
1	0	1	----	9	----	88.1	----	----
2	9	5	954	274	92.3	108.7	7.953	p<0.05
3	12	6	1888	1570	103.9	117.5	18.143	p<0.001
4	13	6	2244	1500	113.5	120.8	4.031	n.s.
5	6	8	805	624	114.6	145.5	28.839	p<0.001
6	3	3	245	56	112.6	170.0	165.804	p<0.001
7	2	2	32	11	132.5	190.0	71.451	p<0.05
8	0	1	----	7	----	195.9	----	----
9	2	0	4	----	133.9	---	----	----

Table 14. Estimated standing stocks in millions of shrimp for depth zones 1-5 in statistical subareas 18-21 during the 1981 and 1982 Texas Closures.

Depth Zones	Statistical Subareas/Years: 18		19		20		21	
	1981	1982	1981	1982	1981	1982	1981	1982
1	-	-	-	-	9.3	6.3	-	-
2	214.3	186.3	118.2	247.1	60.5	124.1	99.7	66.0
3	134.9	54.5	374.9	291.2	327.6	102.7	164.9	151.7
4	28.3	29.3	226.0	44.9	166.0	36.4	122.7	86.7
5	18.3	20.5	25.1	4.6	40.9	3.3	78.7	16.5
Totals:	395.9	290.6	744.2	587.8	604.3	272.8	472.3	320.9

Grand Total for 1981: 2,216.7
Grand Total for 1982: 1,472.1

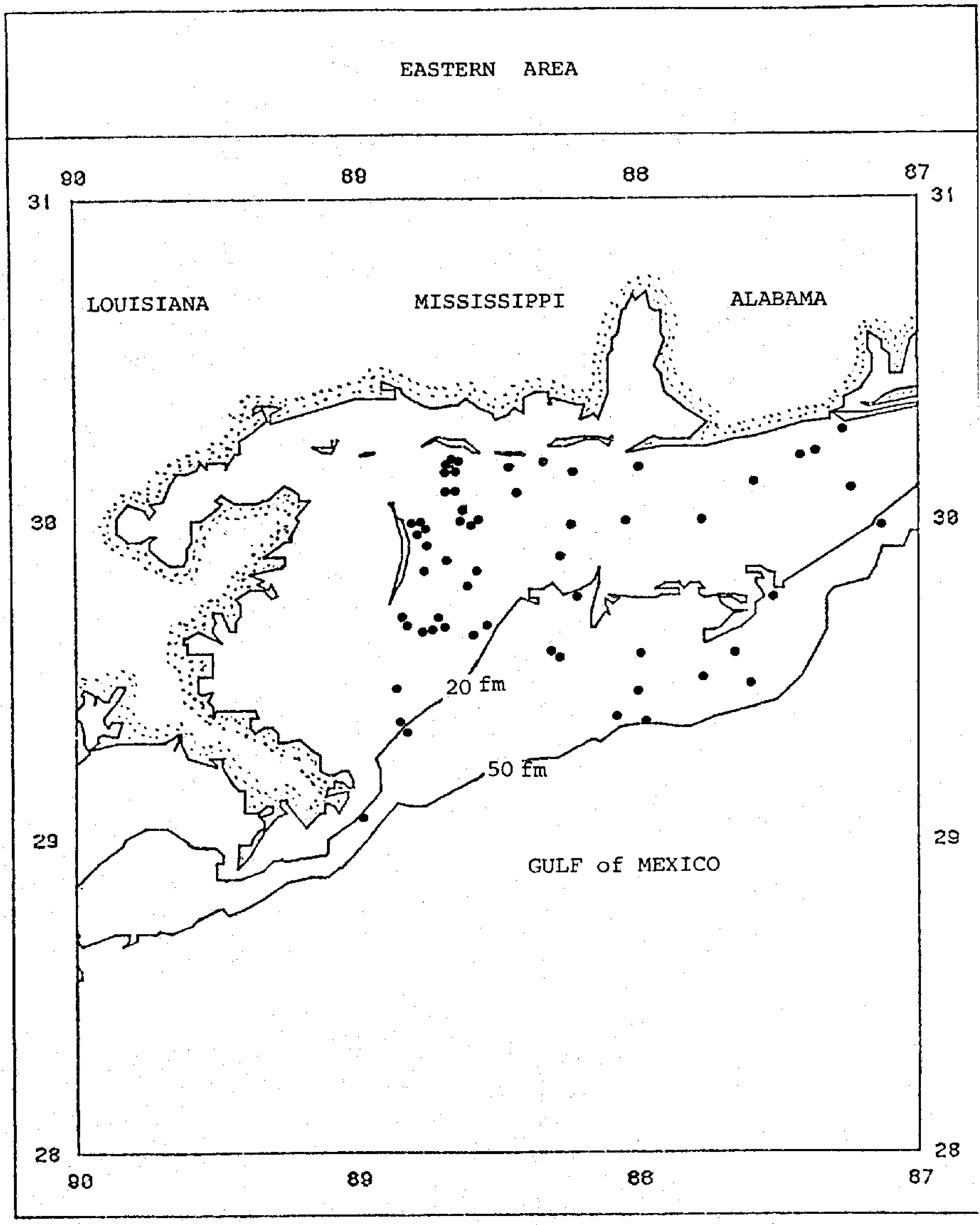

Figure 1. Collection sites off Alabama, Mississippi and Louisiana east of the Mississippi River delta (=Eastern Area), during the Texas Closure, May 26-July 14, 1982.

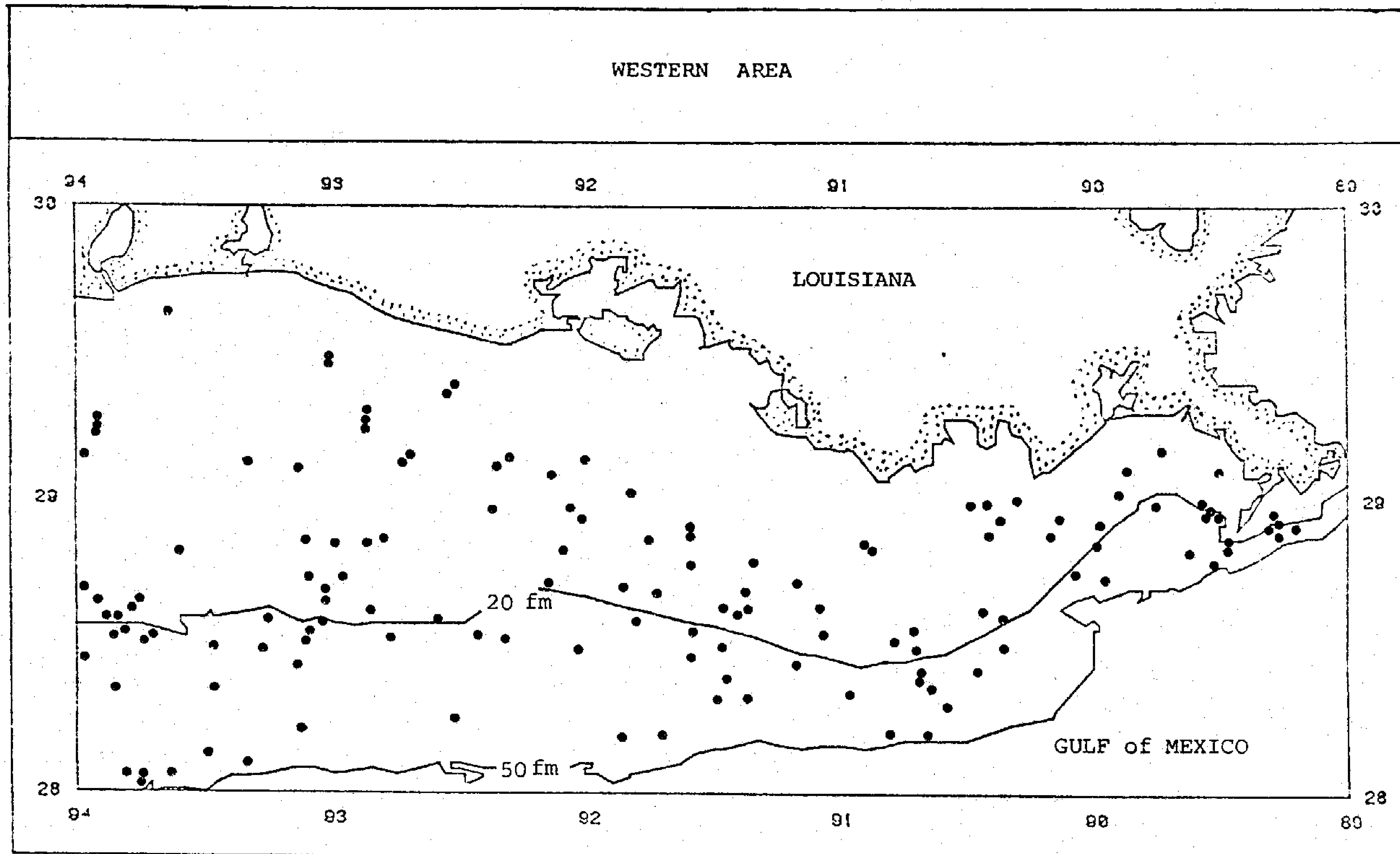

Figure 2. Collection sites off the Louisiana coast and west of the Mississippi River delta (=Western Area) during the Texas Closure, May 26-July 14, 1982

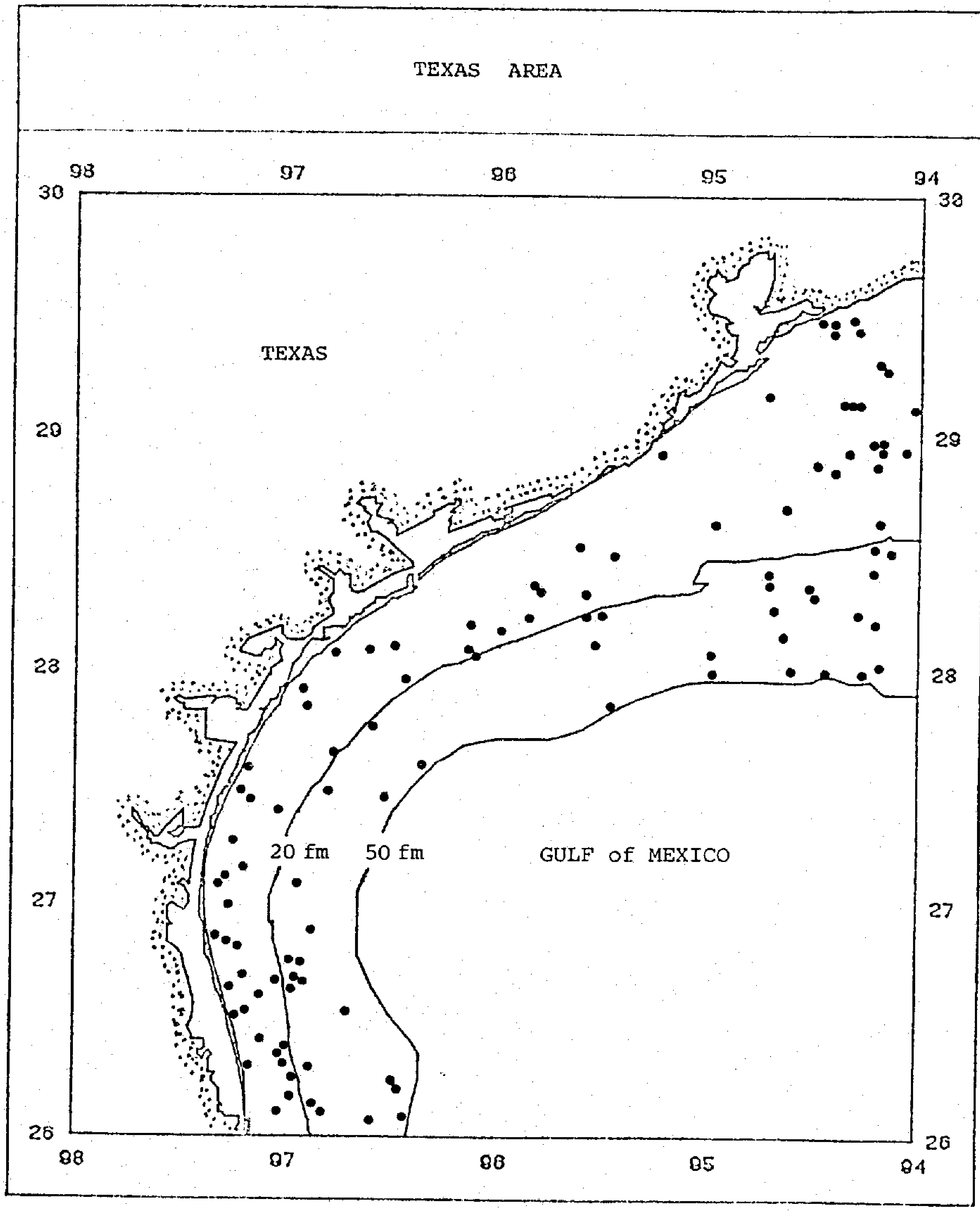

Figure 3. Collection sites in the Texas Area during the Texas Closure, May 26-July 14, 1982.

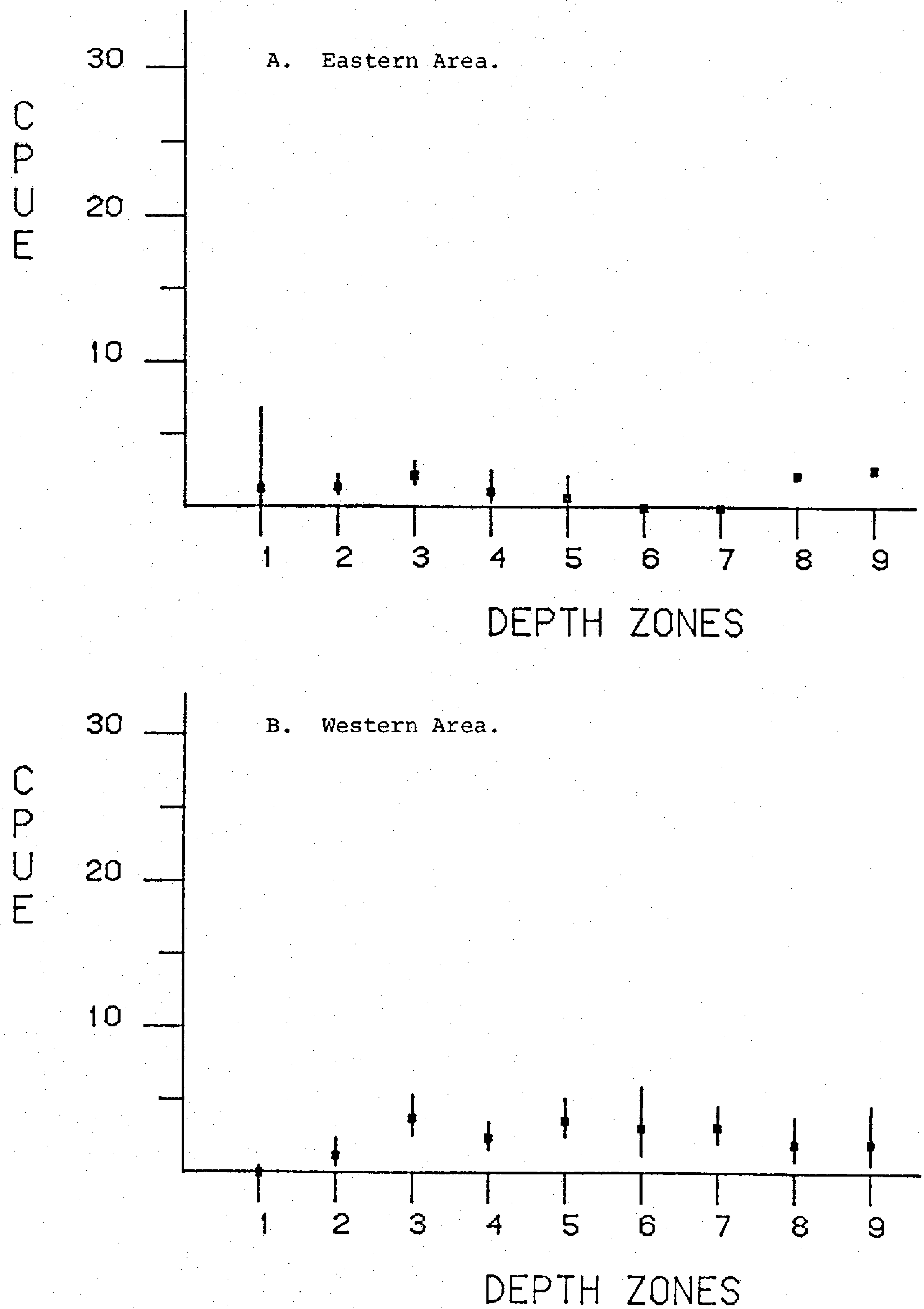

Figure 4. Mean CPUE's and 95% confidence limits for Penaeus spp. shrimp collected in the nine 5-fathom depth zones during May and June, 1982. CPUE's are in lbs. of shrimp/40-ft net/30-min. drag.

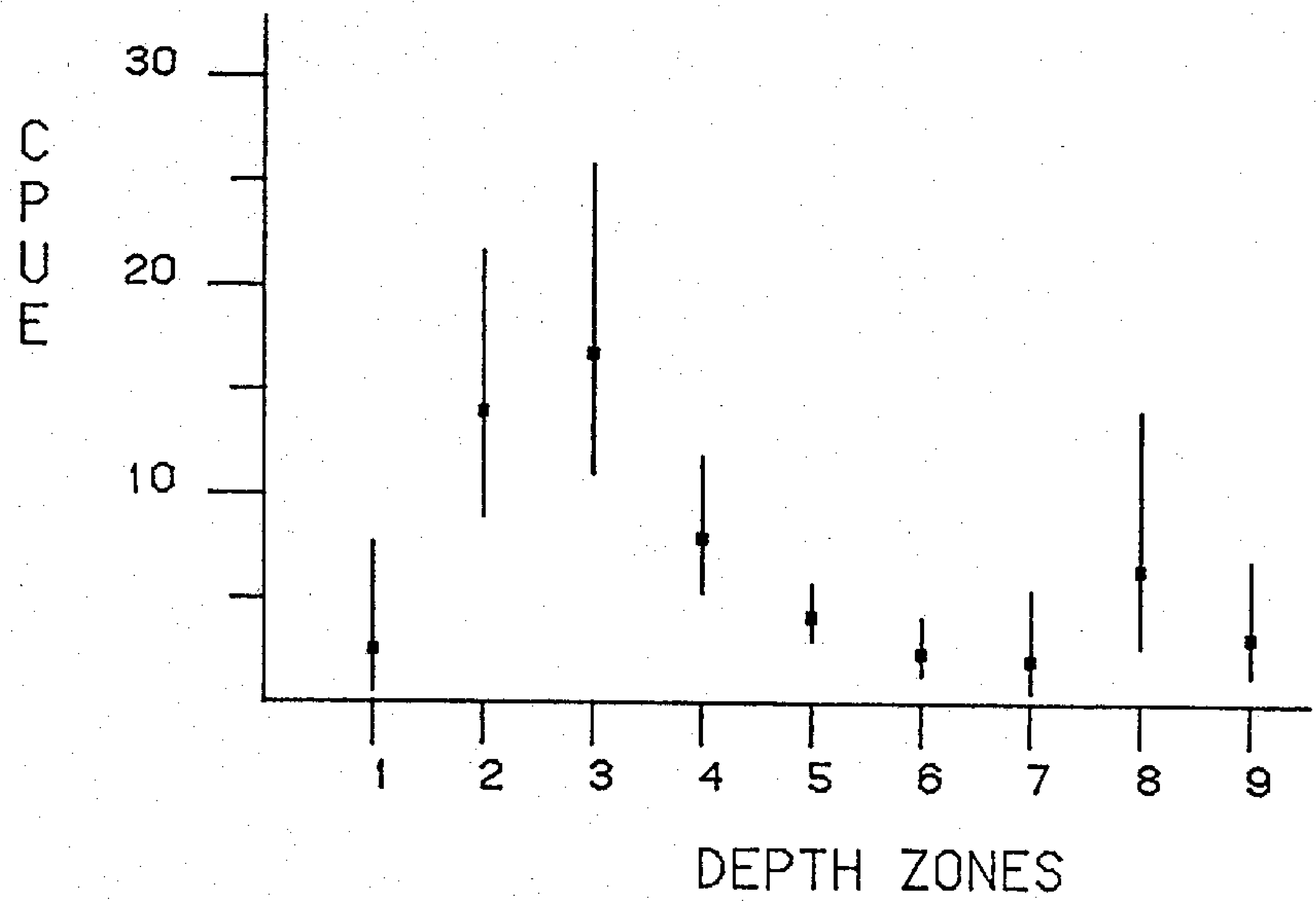

Figure 5. Mean CPUE's and 95% confidence limits for Penaeus spp. shrimp collected in the nine 5-fathom depth zones in the Texas Area during July, 1982. CPUE's are in lbs. of shrimp/40-ft net/30-min drag.

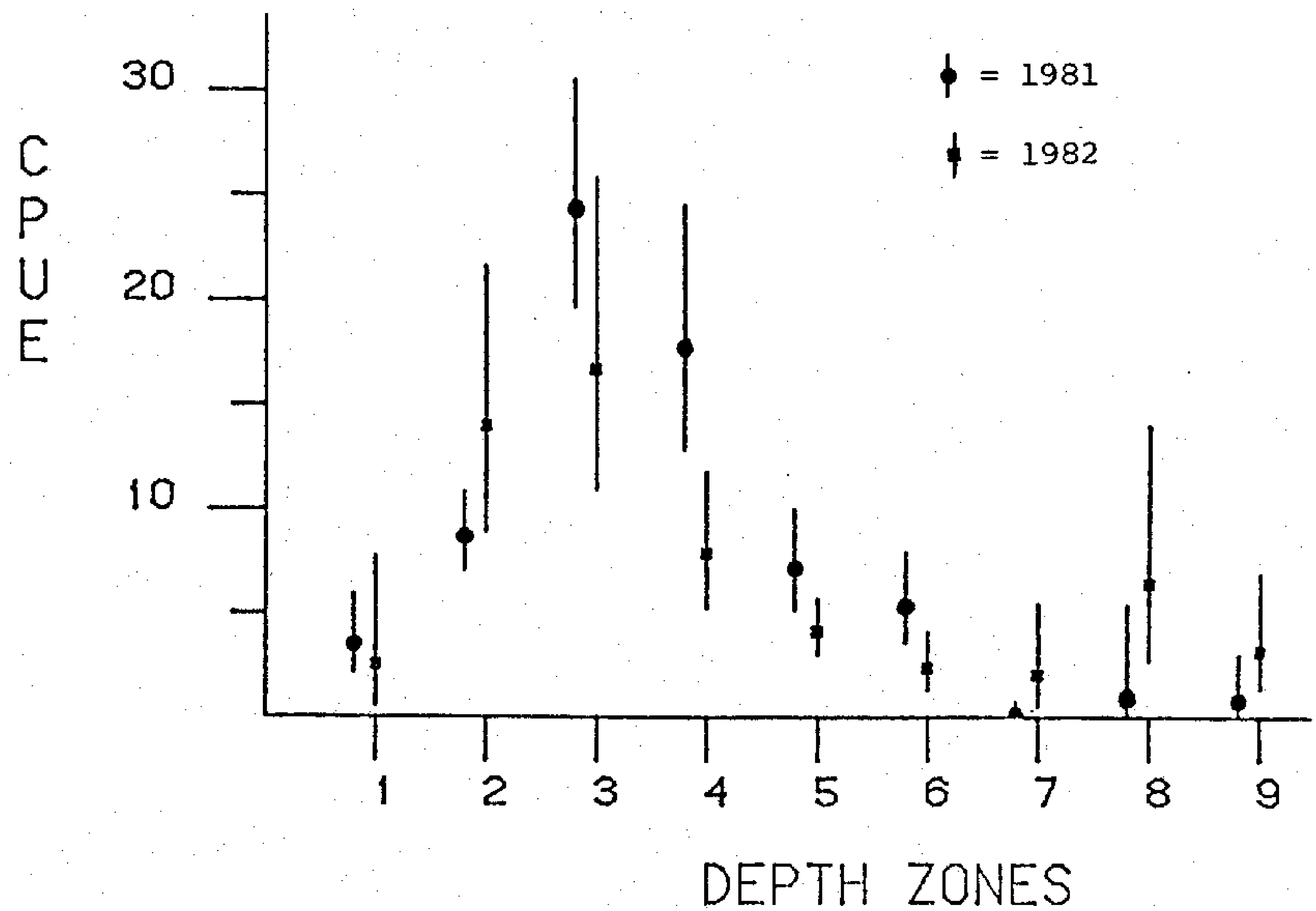

Figure 6. Mean CPUE's and 95% confidence limits for Penaeus spp. shrimp collected in the nine 5-fathom depth zones in the Texas Area during the 1981 and 1982 Texas Closures. CPUE's are in lbs of shrimp/40-ft net/30-min drag.

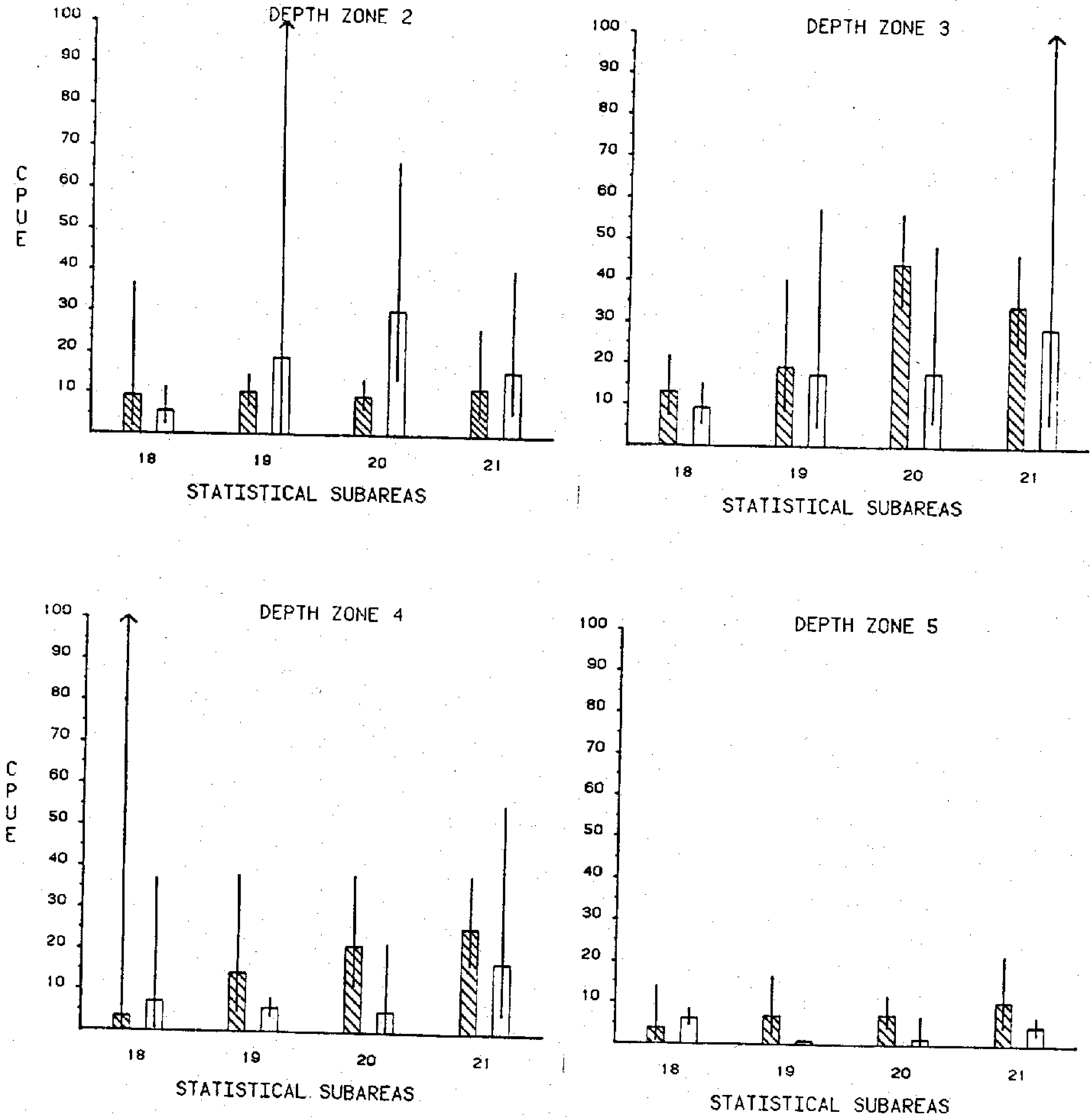

Figure 7. Mean CPUE's and 95% confidence limits for shrimp collected in depth zones 2-5 in statistical subareas 18-21 (= Texas Area) during the 1981 and 1982 Texas Closures. The cross-hatched bars represent 1981 means, and the clear bars represent 1982 means. CPUE's are in lbs of shrimp/40-ft net/30-min drag. Arrows at the top of the confidence limits indicate the upper limit extends beyond the Y-axis maximum.

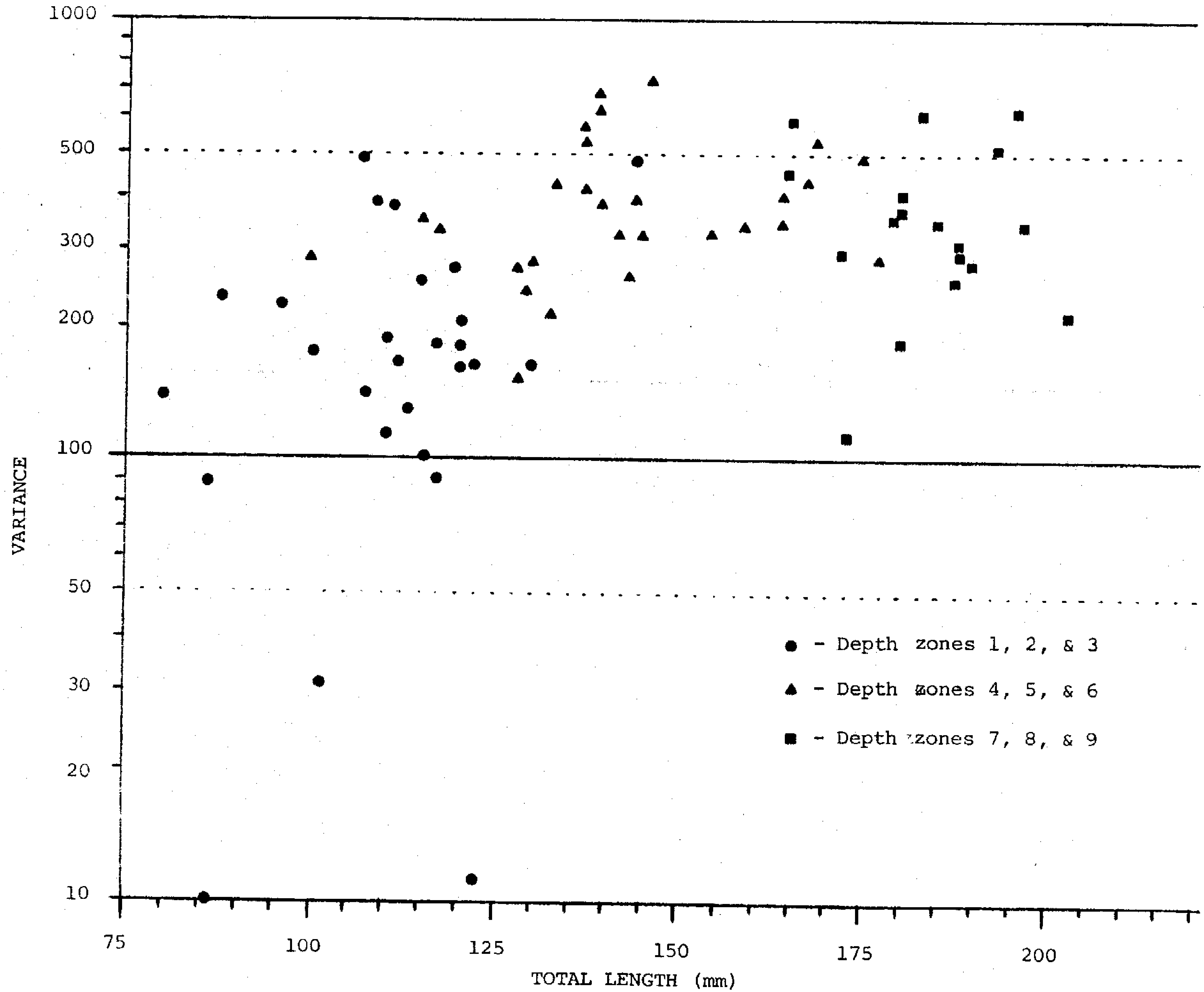

Figure 8. Relationships between means and variances for brown shrimp lengths based on data collected from depth zones 1-9 in statistical subareas 18-21 during the 1982 closure period.

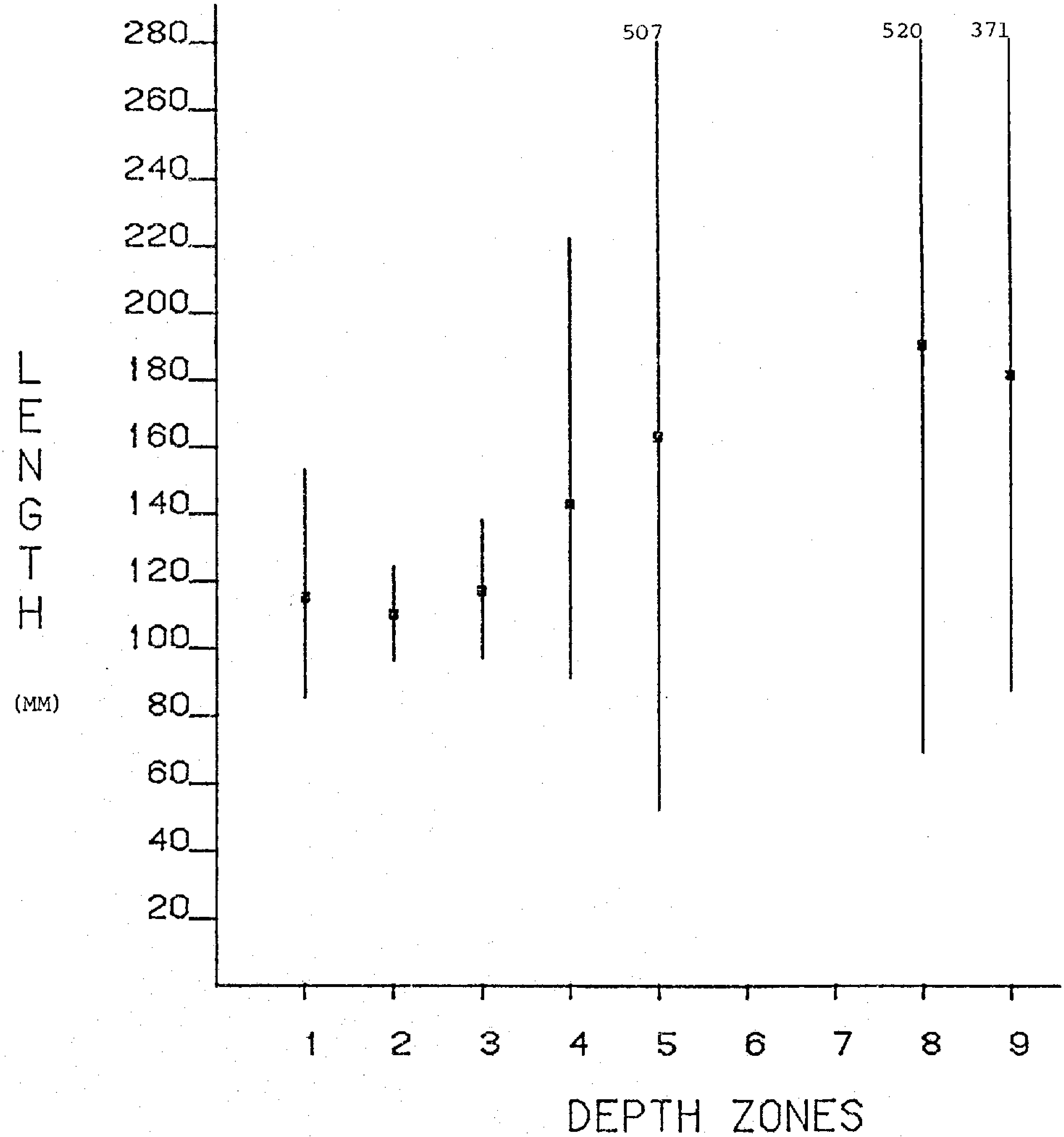

Figure 9. Mean total lengths and 95% confidence limits for brown shrimp collected in the Eastern Area during the 1982 closure period. Means and limits were calculated from $\log_{10}$-transformed data.

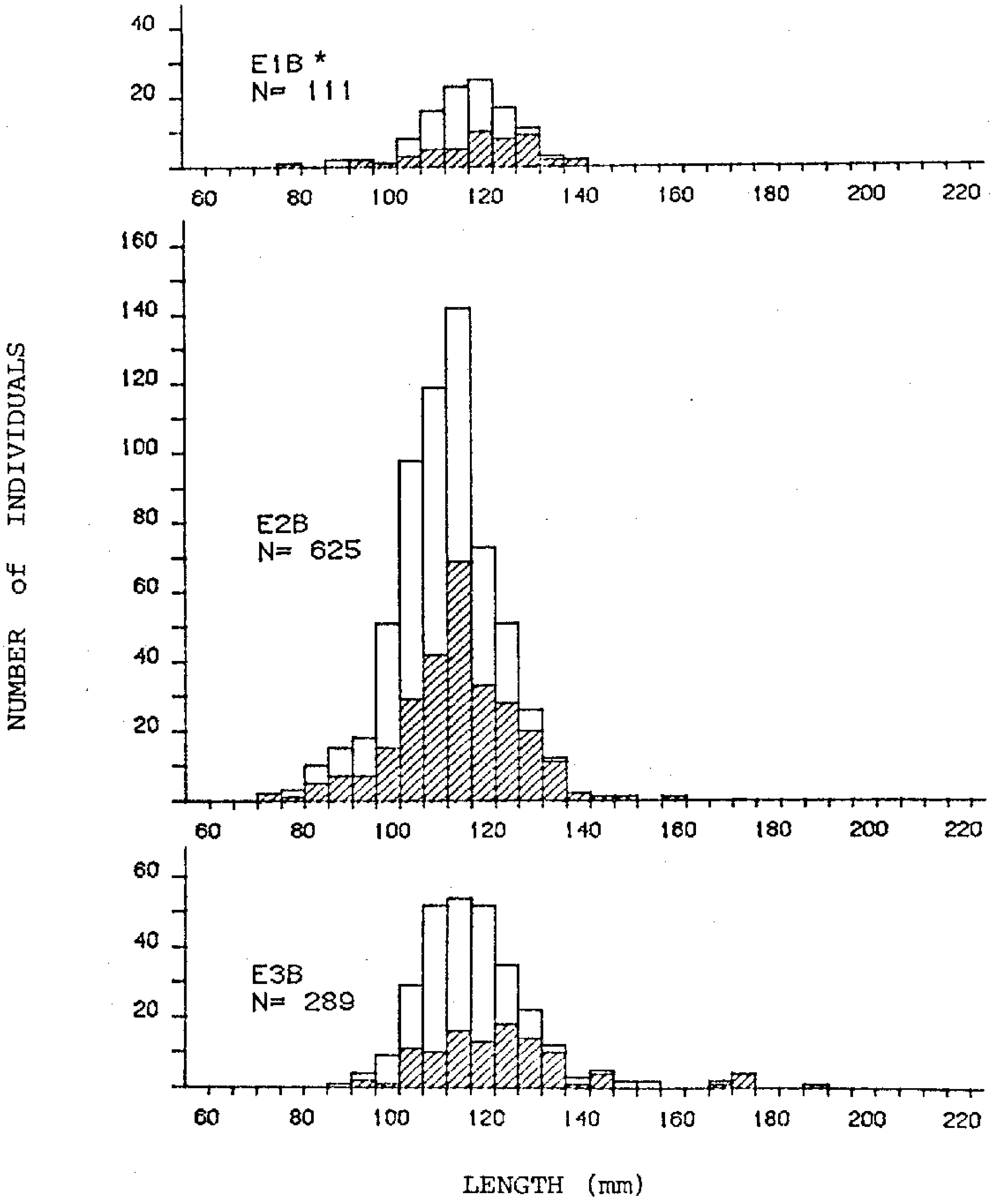

Figure 10. Length-frequency distributions of brown shrimp collected in depth zones 1-3 in the Eastern Area during May and June, 1982. The cross-hatched portion of a bar represents females, the open portion represents males.
*E1B: E=Eastern Area, 1=depthzone 1, and B=brown shrimp.

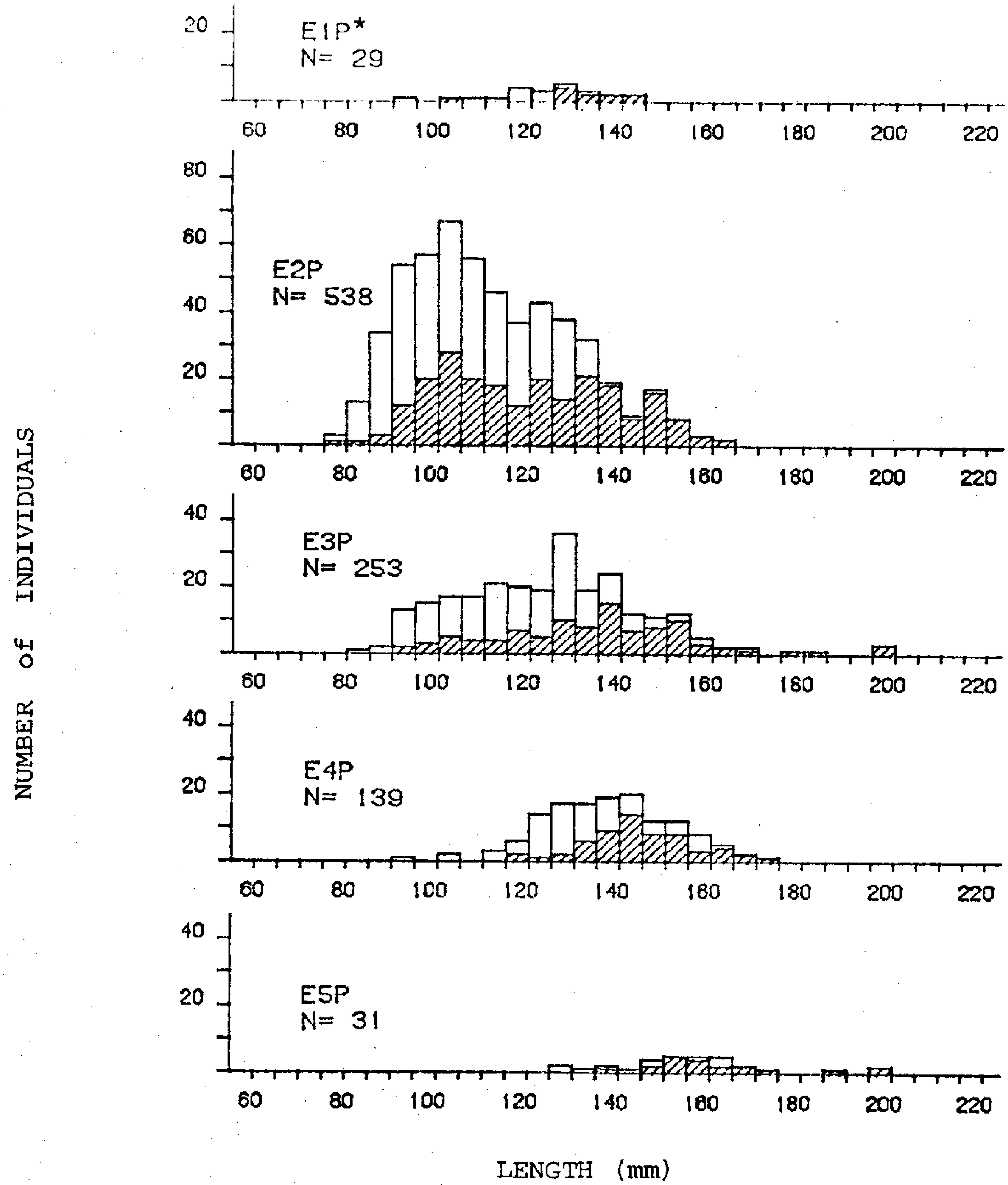

Figure 11. Length-frequency distributions of pink shrimp collected in depth zones 1-5 in the Eastern Area during May and June, 1982. The cross-hatched portion on a bar represents females, and the open portion represents males.
*E1P: E=Eastern Area, 1=depth zone 1, and P=pink shrimp.

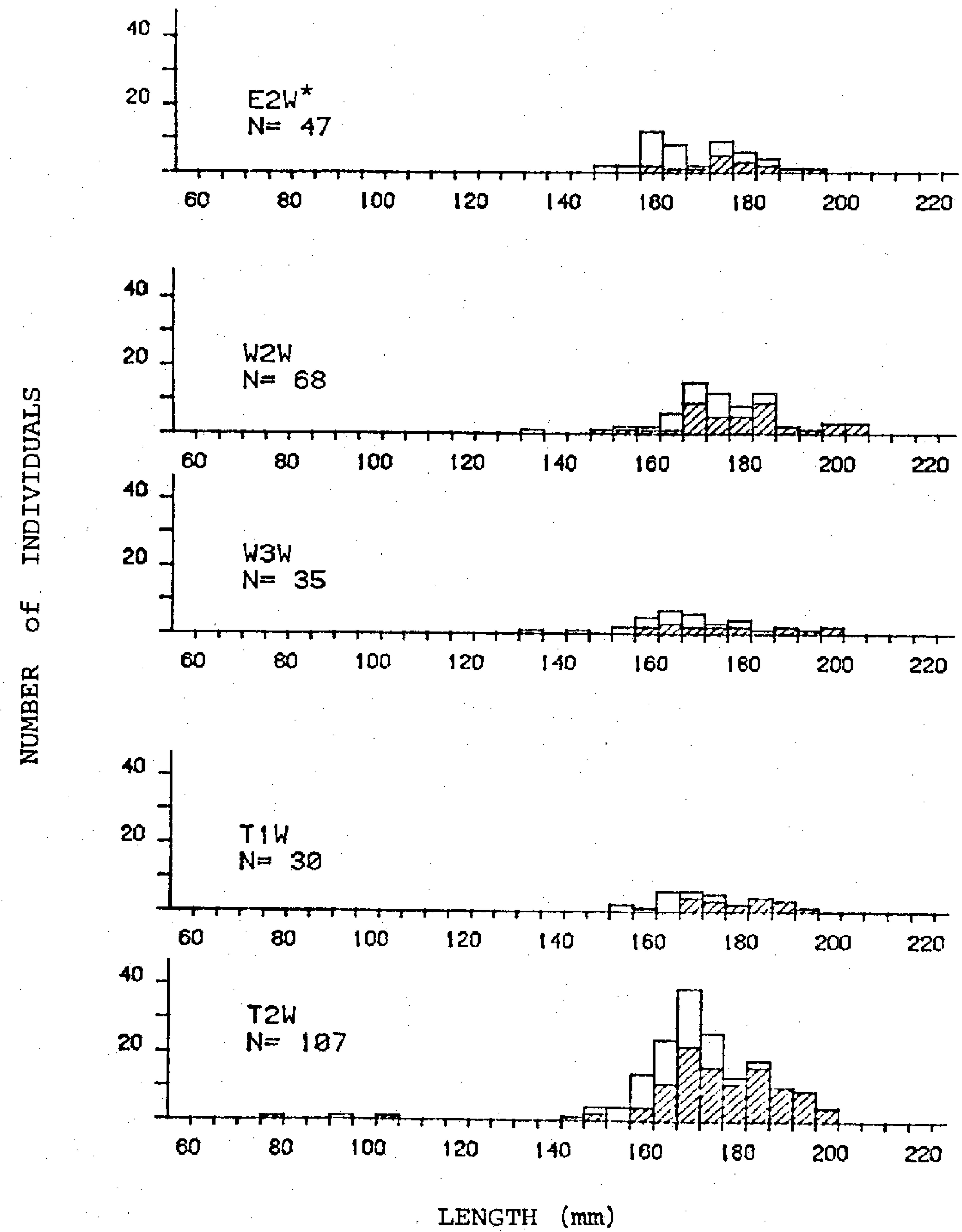

Figure 12. Length-frequency distributions of white shrimp collected in all three major sampling areas of the 1982 closure (May-July). The cross-hatched portion of a bar represents females, and the open portion represents males.
*E2W: E=Eastern Area, 2=depth zone 2, and W=white shrimp.

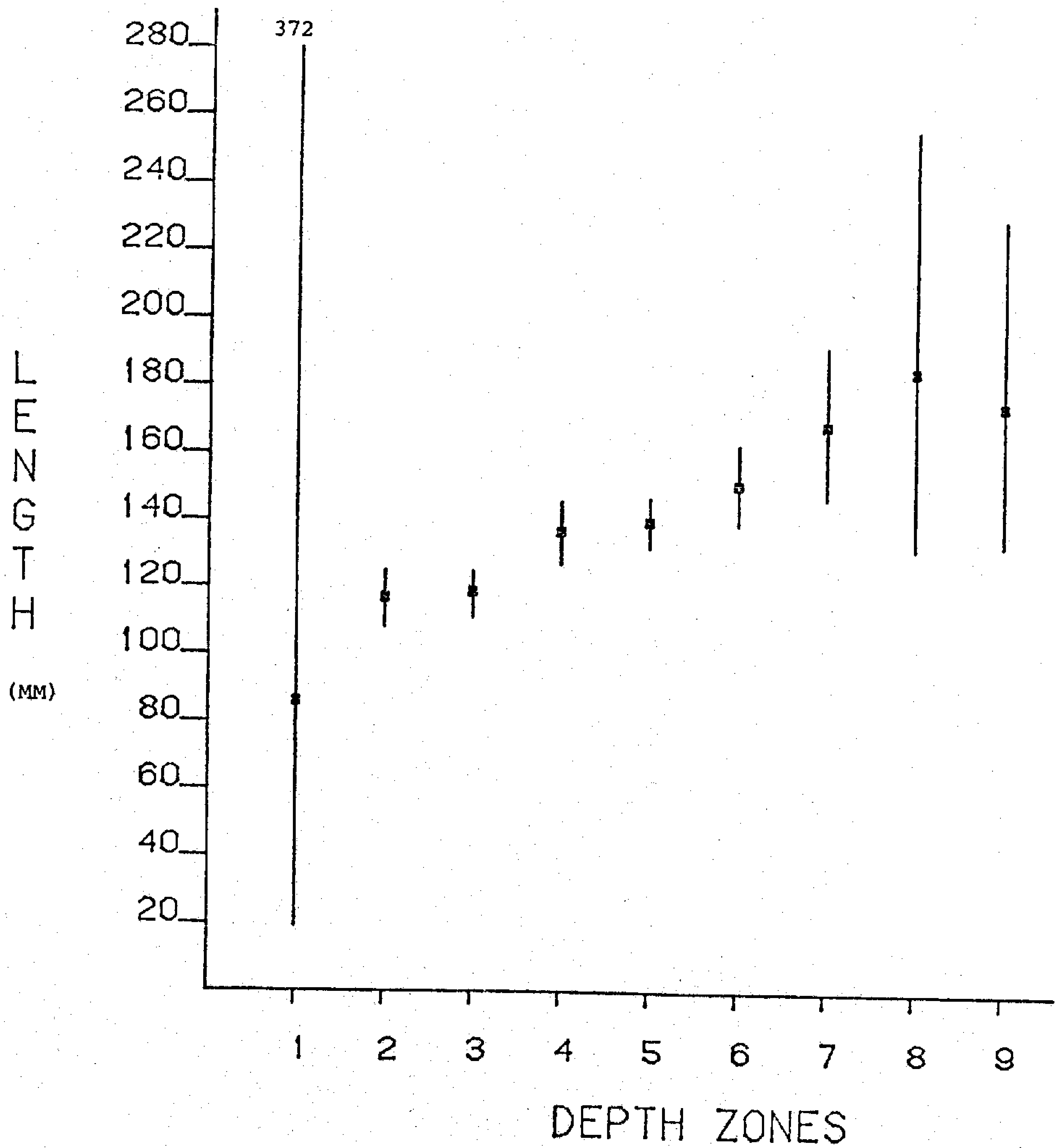

Figure 13. Mean total lengths and 95% confidence limits for brown shrimp collected in depth zones 1-9 of the Western Area during June, 1982. Means and limits were calculated from $\log_{10}$-transformed measurements.

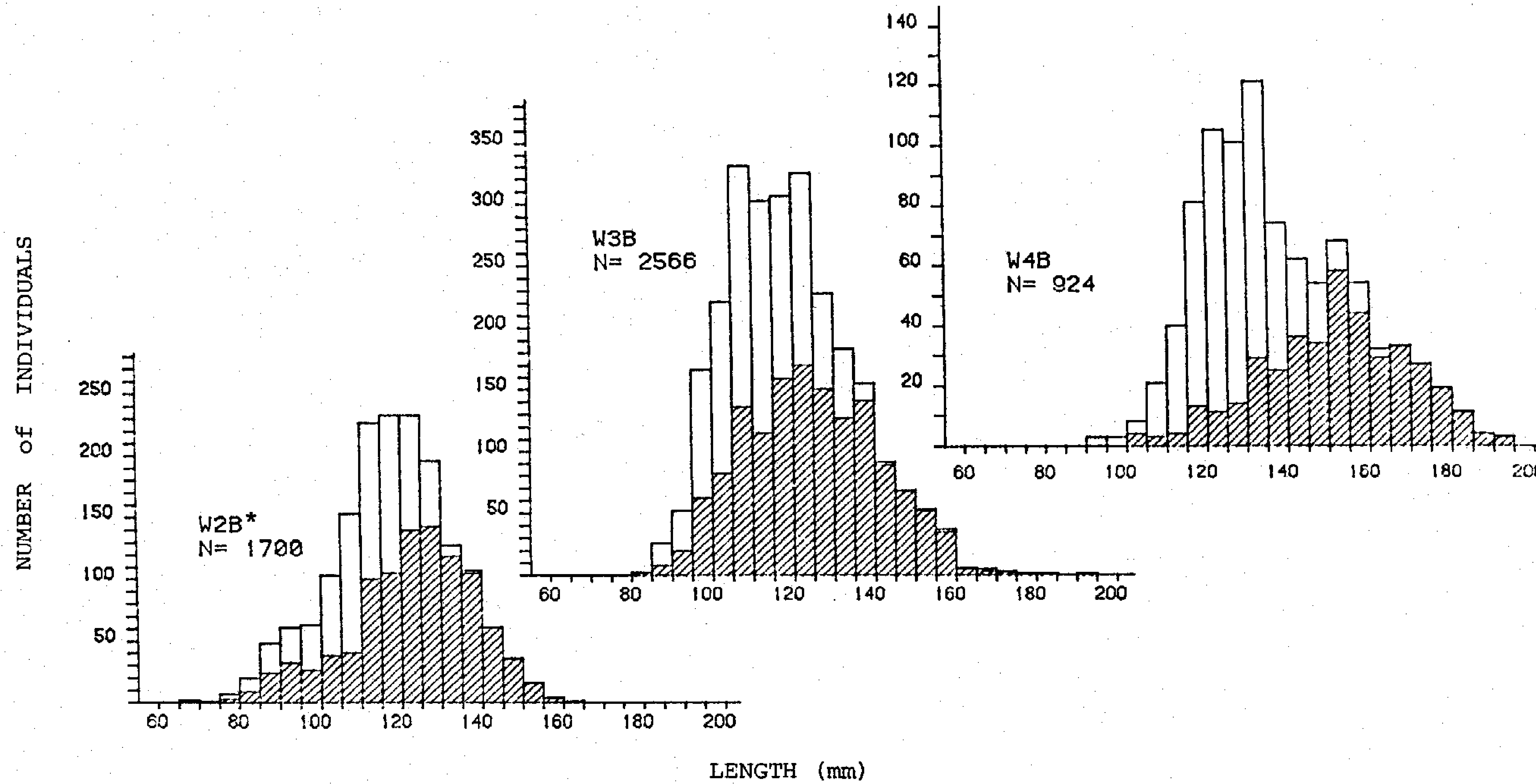

Figure 14. Length-frequency distributions of brown shrimp collected in depth zones 2-4 in the Western Area during June, 1982. The cross-hatched portion of a bar represents females, and the open portion represents males.
*W2B: W=Western Area, 2=depth zone 2, and B=brown shrimp.

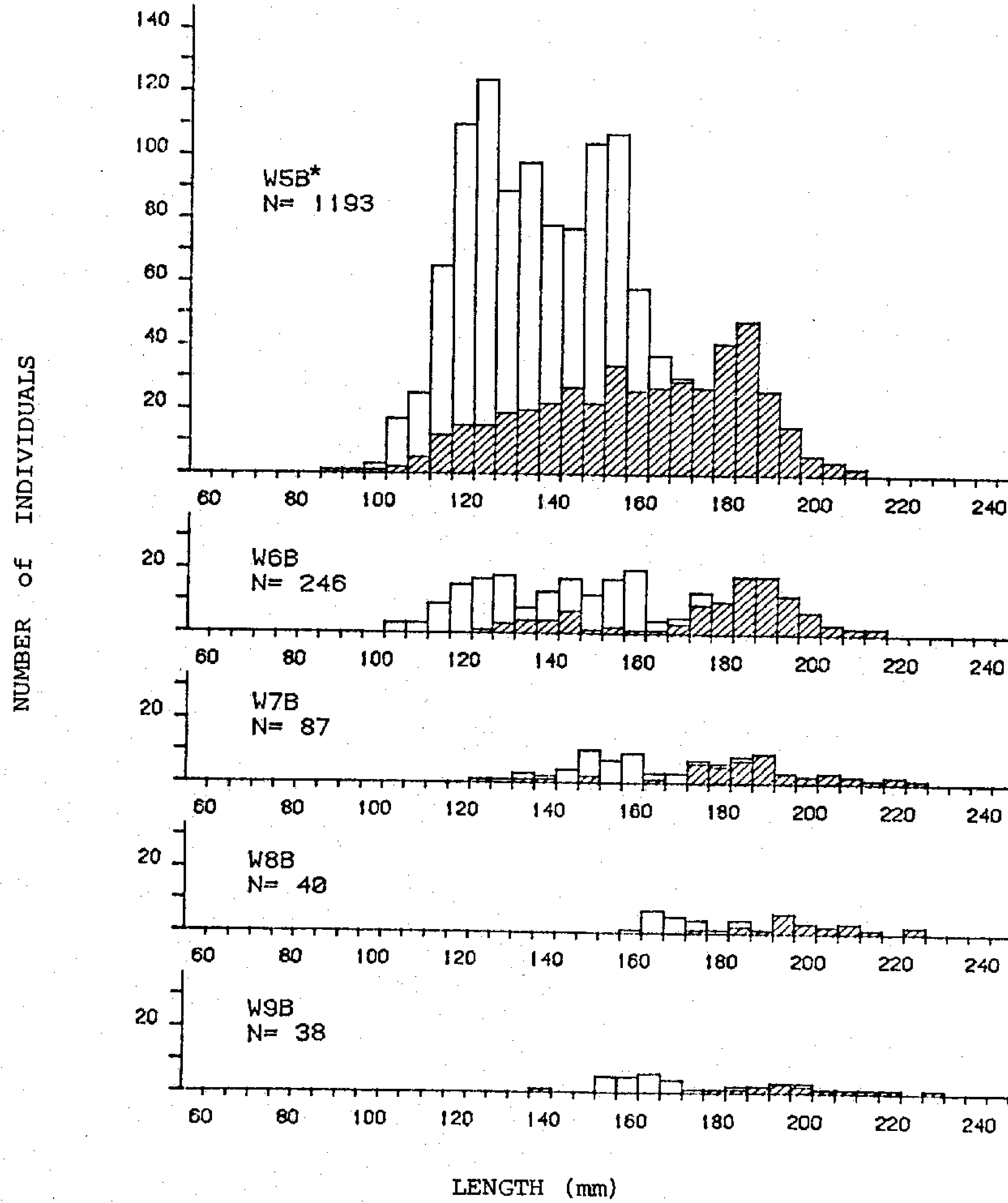

Figure 15. Length-frequency distributions of brown shrimp collected in depth zones 5-9 in the Western Area during June, 1982. The cross-hatched portion of a bar represents females, and the clear portion represents males.
*W5B: W=Western Area, 5=depth zone 5, and B=brown shrimp.

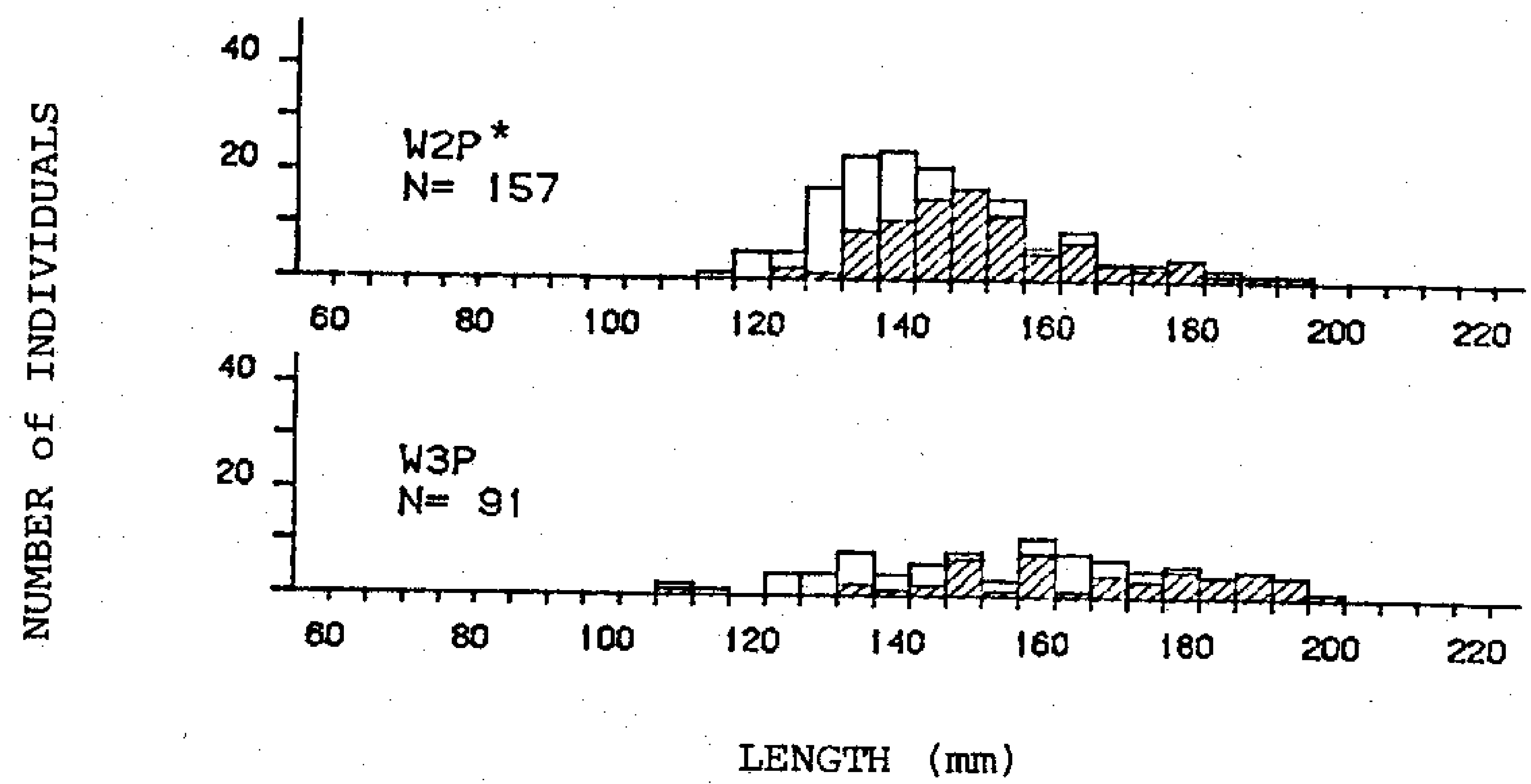

Figure 16. Length-frequency distributions of pink shrimp collected in depth zones 2 and 3 of the Western Area during June, 1982. The cross-hatched portion of a bar represents females, and the open portion represents males.
*W2P: W=Western Area, 2=depth zone 2, and P=pink shrimp.

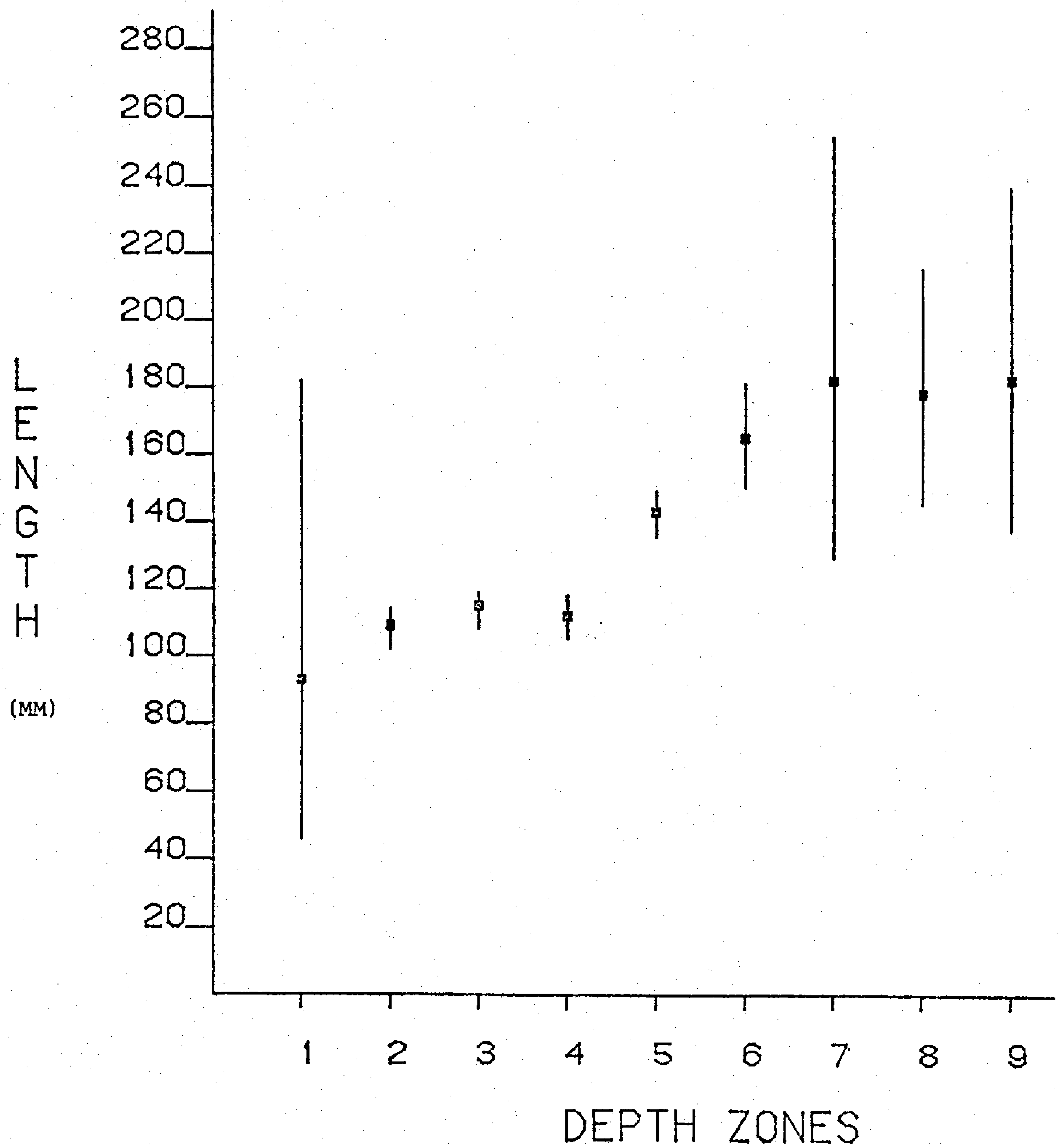

Figure 17. Means and 95% confidence limits for total lengths of brown shrimp collected from depth zones 1-9 off Texas during the 1982 closure period. Means and limits are based on log-transformed original measurements.

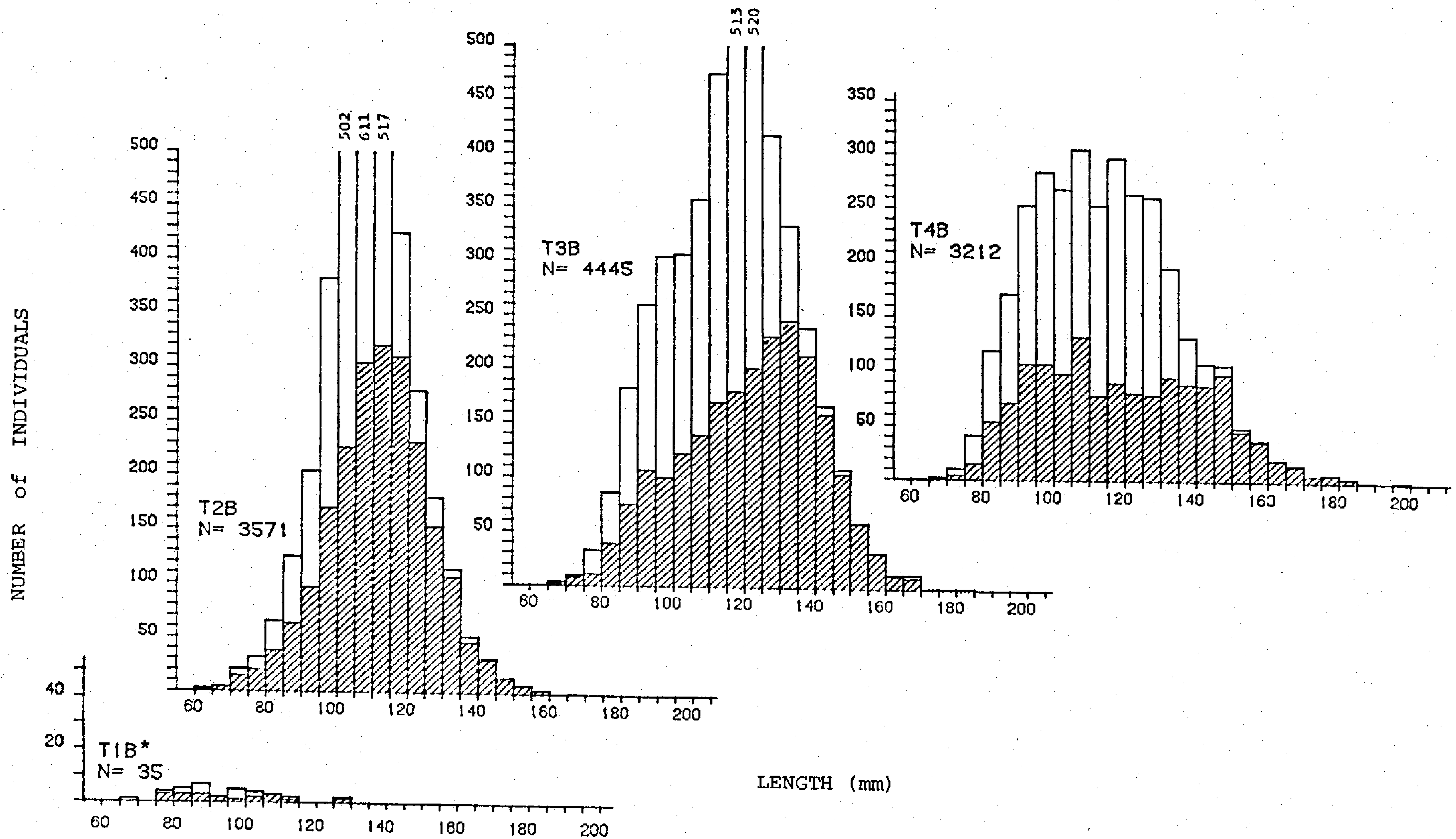

Figure 18. Length-frequency distributions of brown shrimp collected in depth zones 1-4 in the Texas Area during July, 1982. The cross-hatched portion of a bar represents females, and the open portion represents males.
*T1B: T=Texas Area, 1=depth zone 1, and B=brown shrimp.

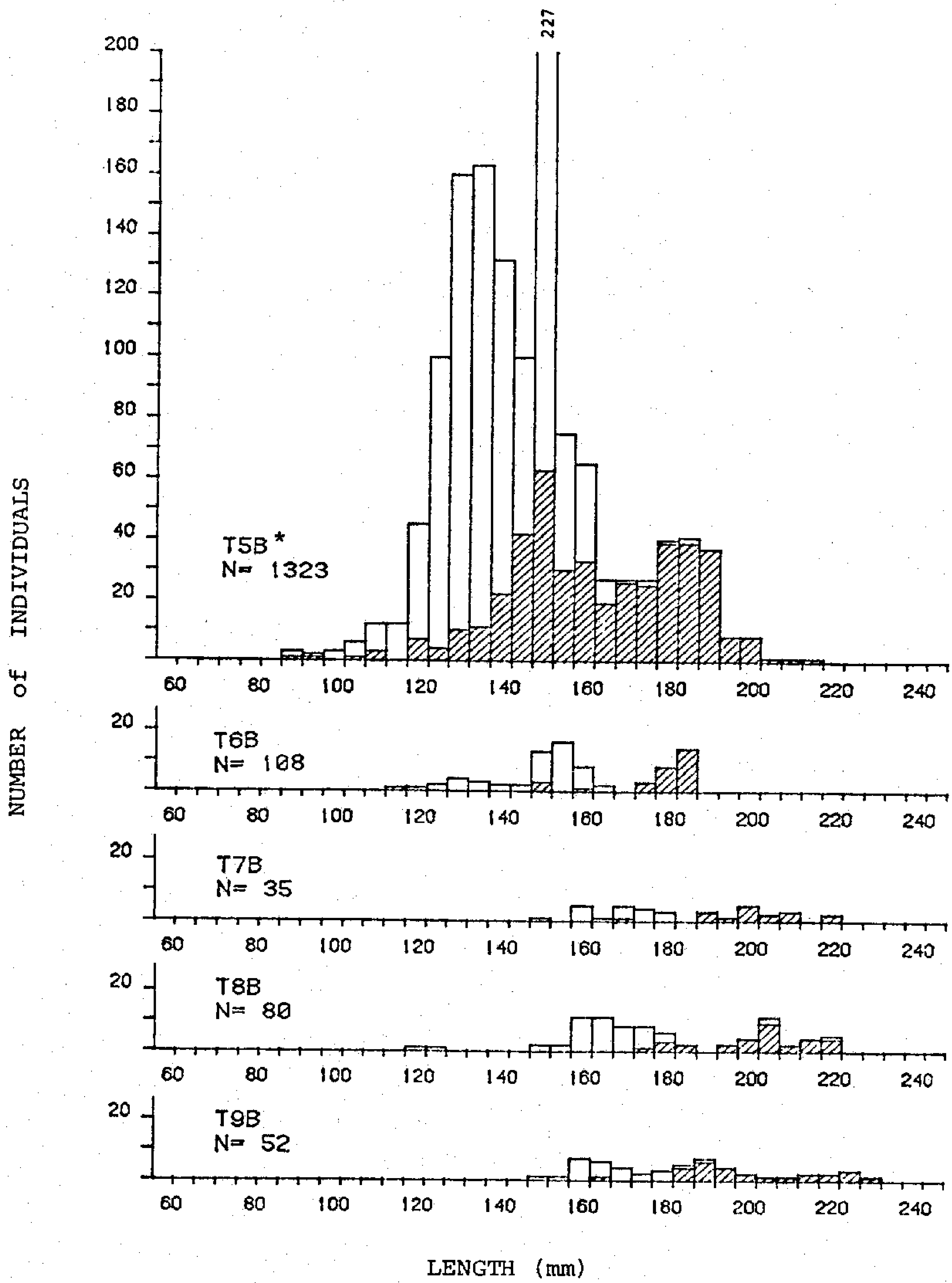

Figure 19. Length-frequency distributions of brown shrimp collected in depth zones 5-9 in the Texas Area during July, 1982. The cross-hatched portion of a bar represents females, and the open portion represents males.
*T5B: T=Texas Area, 5=depth zone 5, and B=brown shrimp.

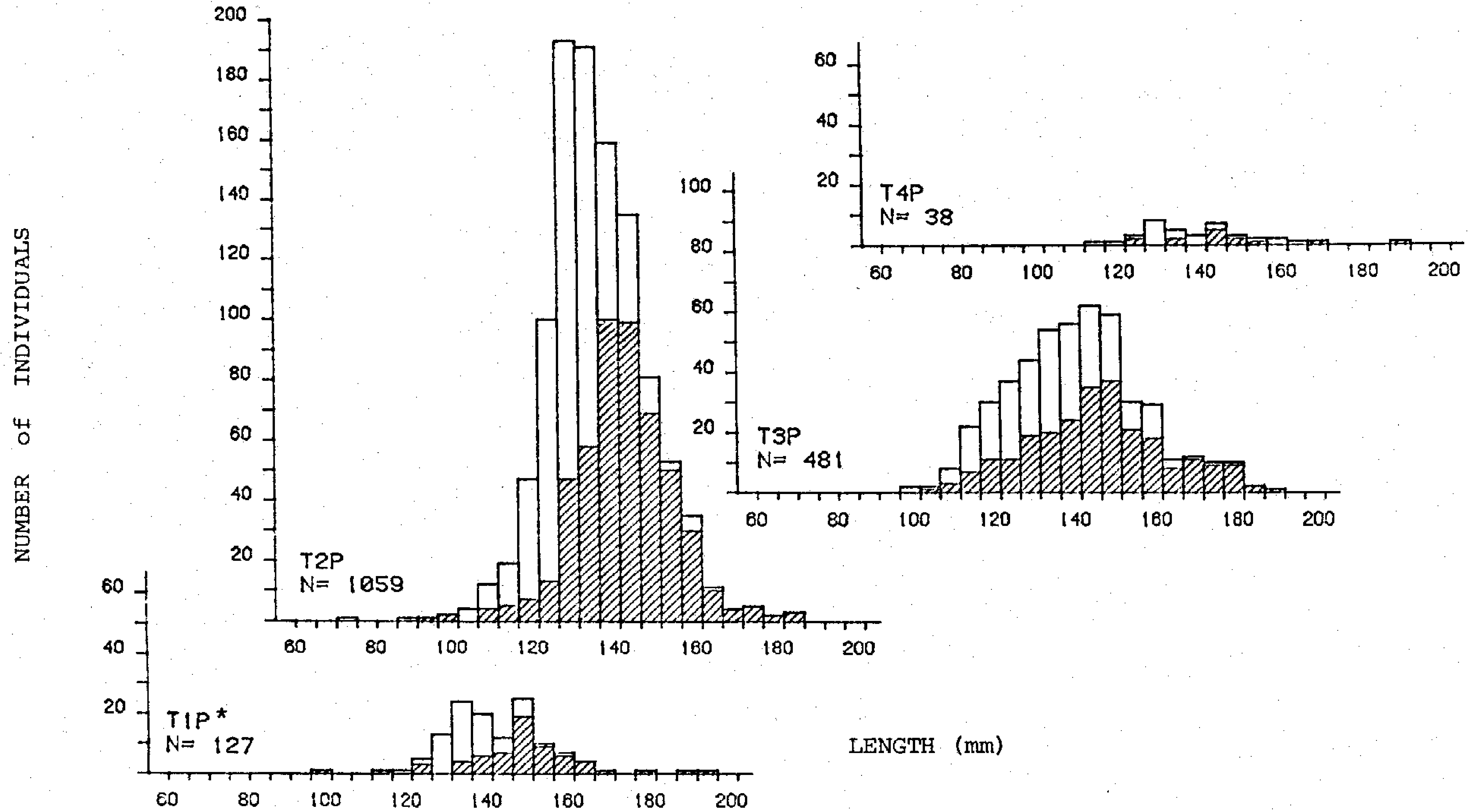

Figure 20. Length-frequency distributions of pink shrimp collected in depth zones 1-4 in the Texas Area during July, 1982. The cross-hatched portion of a bar represents females, and the clear portion represents males.
*T1P: T=Texas Area, 1=depth zone 1, and P=pink shrimp.

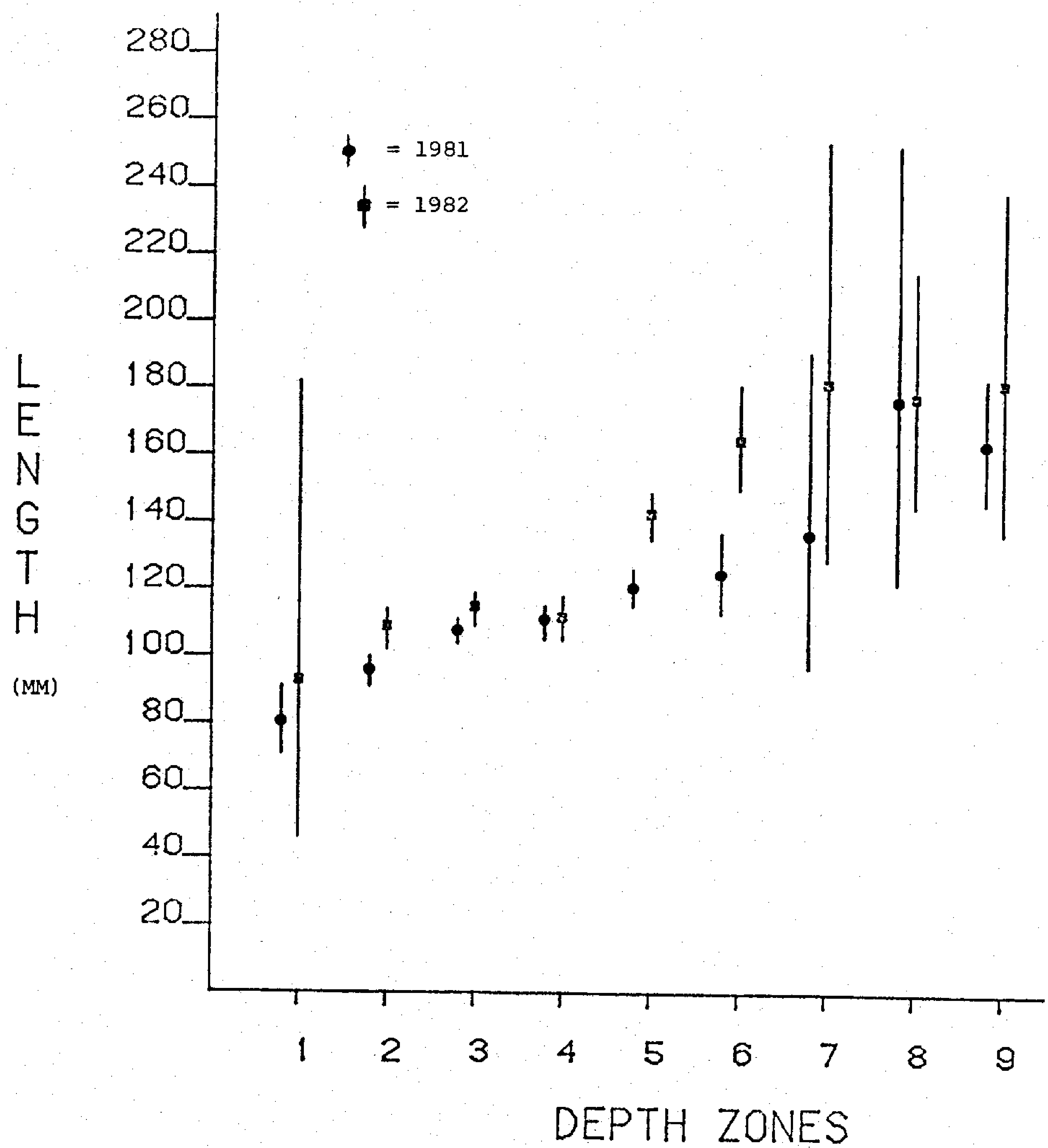

Figure 21. Mean total lengths and 95% confidence limits for brown shrimp collected in depth zones 1-9 of the Texas Area during the 1981 and 1982 Texas closures. Means and limits were calculated from $\log_{10}$-transformed measurements.

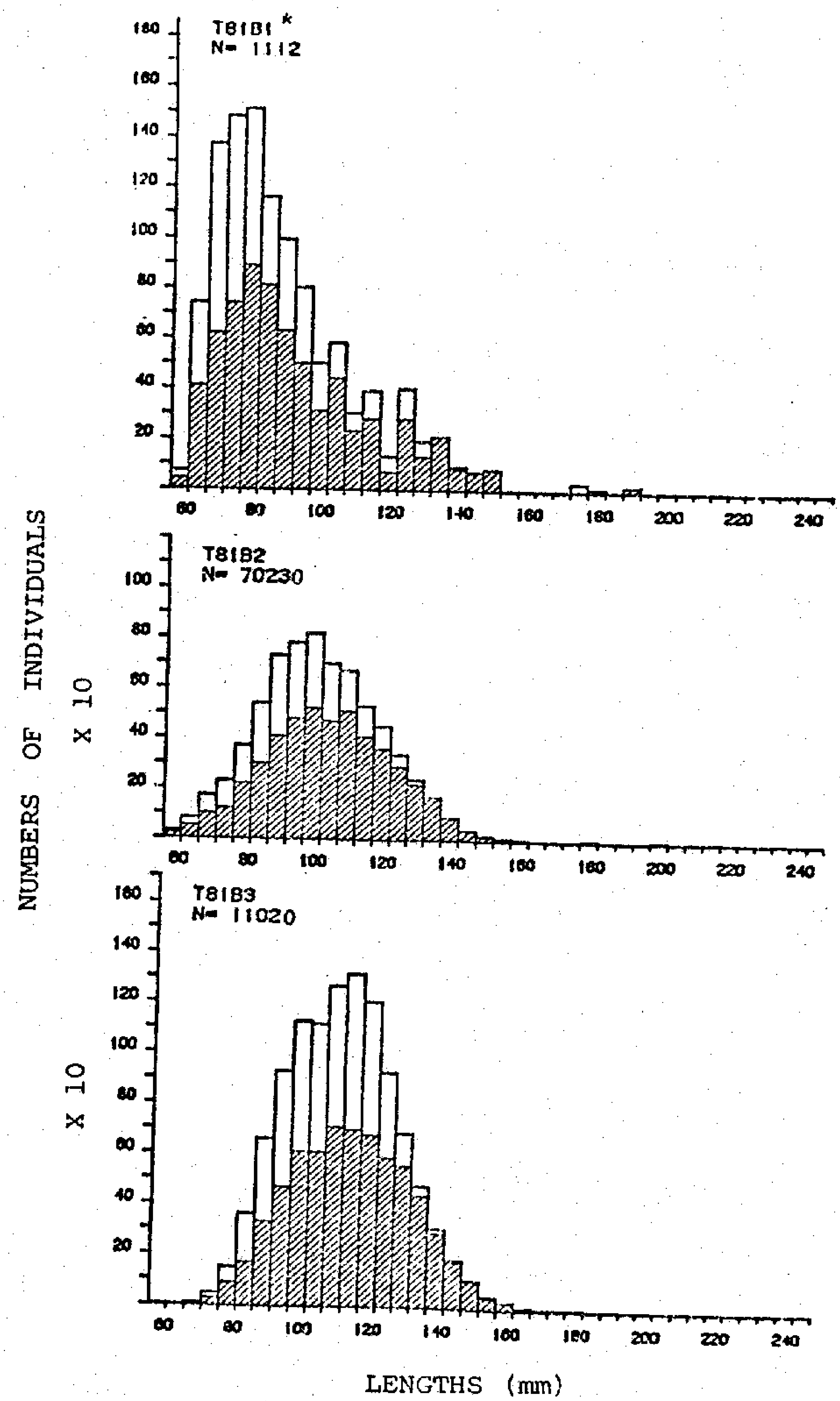

Figure 22. Length-frequency distributions for brown shrimp clooected in depth zones 1-3 in the Texas Area during the 1981 Texas closure. The cross-hatched portion of a bar represents females, and the open portion represents males.
*T81B1: T=Texas Area, 81=1981, B=brown shrimp, and 1=depth zone 1.

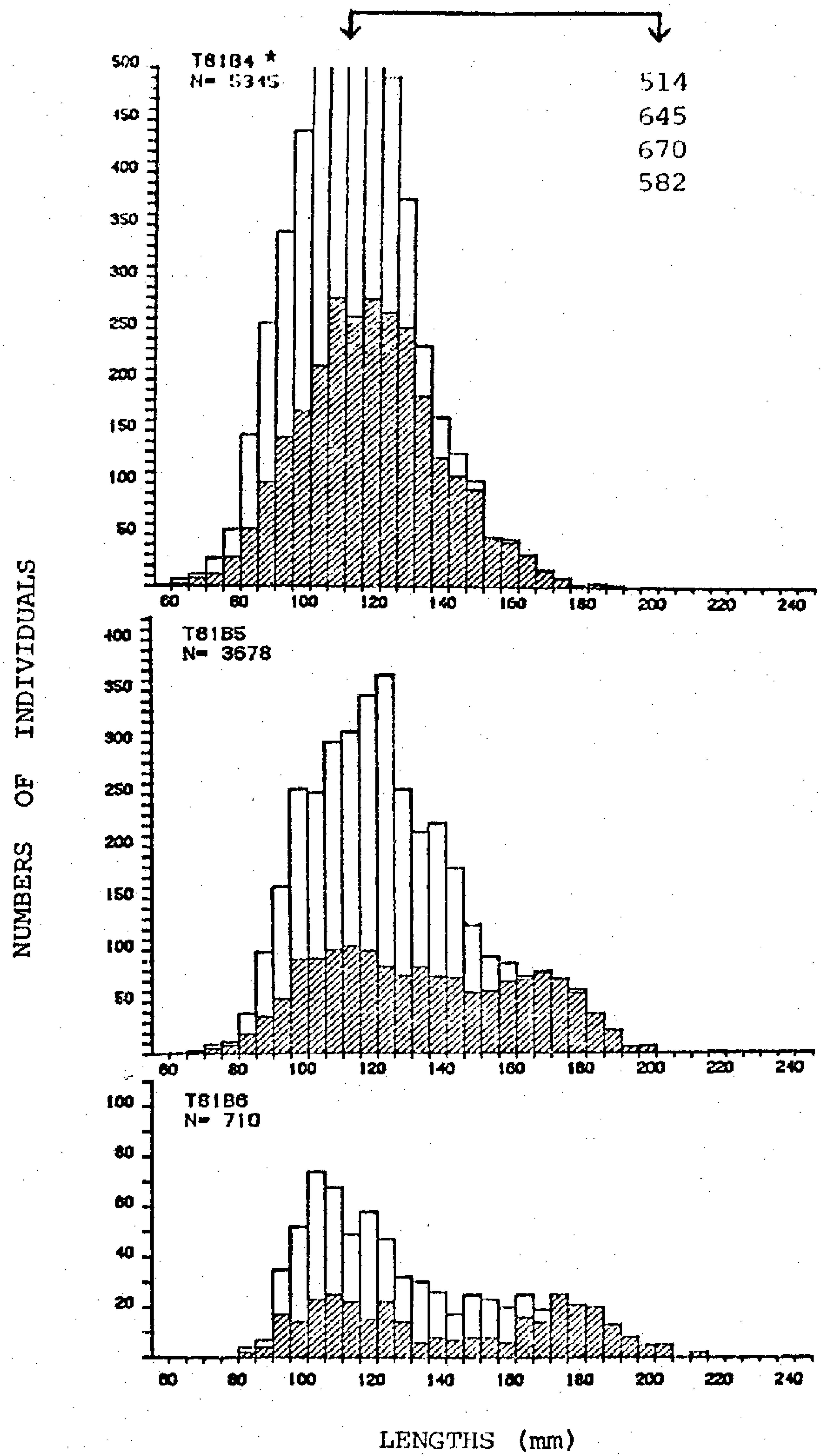

Figure 23. Length-frequency distributions for brown shrimp collected in depth zones 4-6 in the Texas Area during the 1981 Texas closure. The cross-hatched portion of a bar represents females, and the open portion represents males.

*T81B4: T=Texas Area, 81=1981, B=brown shrimp, and 4=depth zone 4.

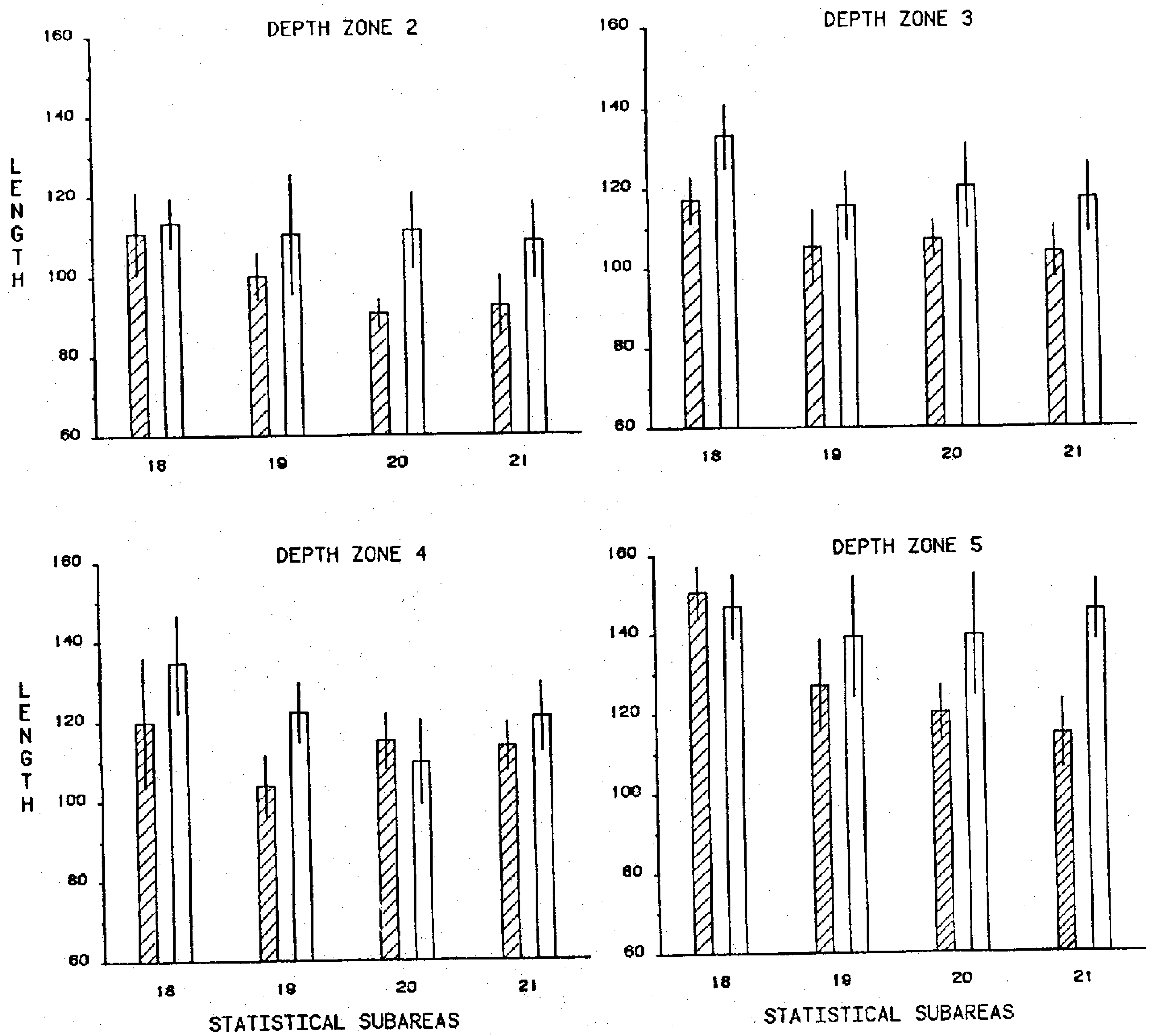

Figure 24. Mean lengths and 95% confidence limits for brown shrimp collected in depth zones 2-5 in statistical subareas 18-21 of the Texas Area during the 1981 and 1982 Texas closures. The cross-hatched bars represent the 1981 means, and the clear bars represent the 1982 means.

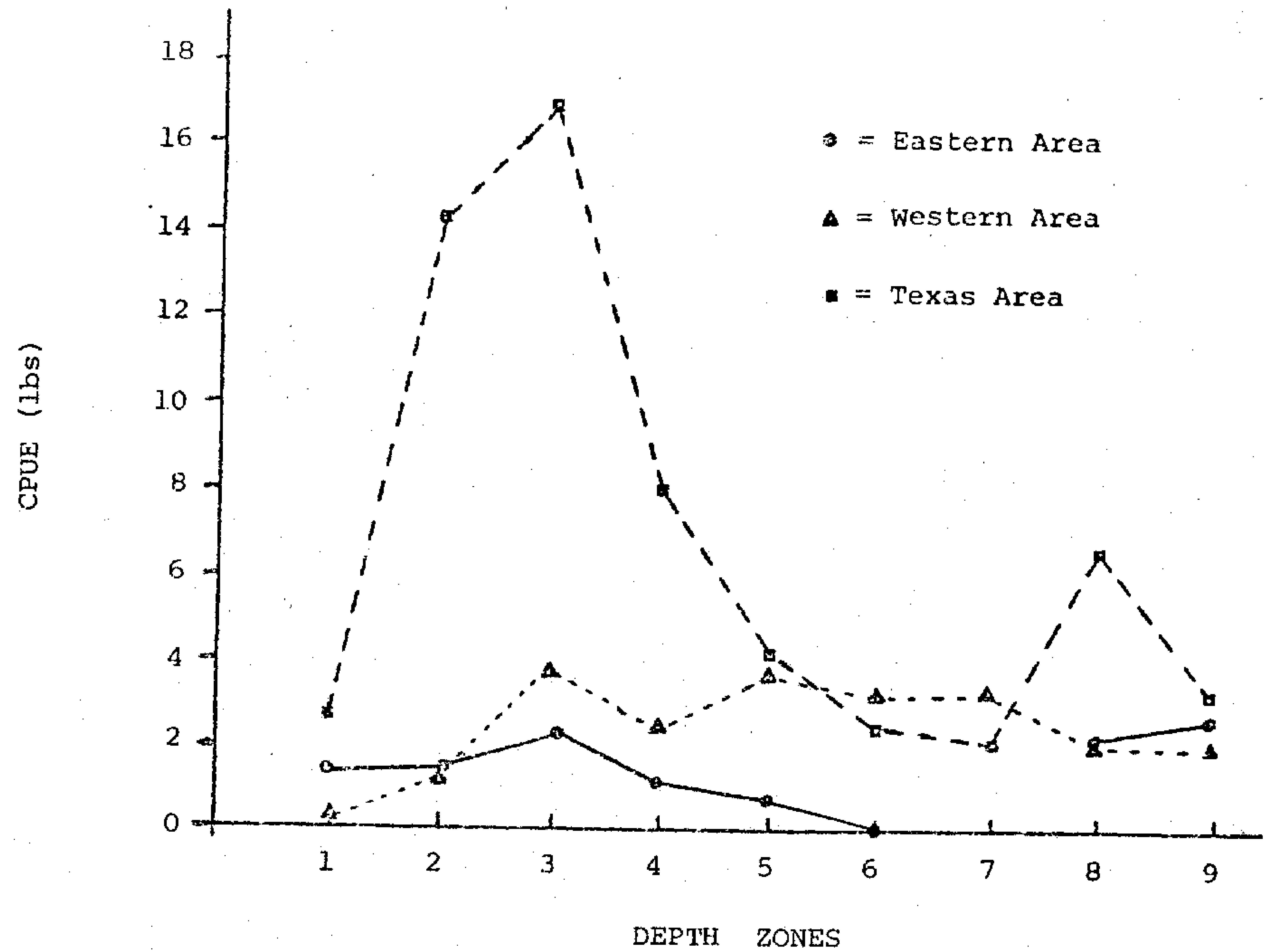

Figure 25. Relative abundances of shrimp in the nine 5-fathom depth zones in the three major sampling areas studied during the 1982 closure. CPUE's are in lbs of shrimp/40-ft net/30-min drag.

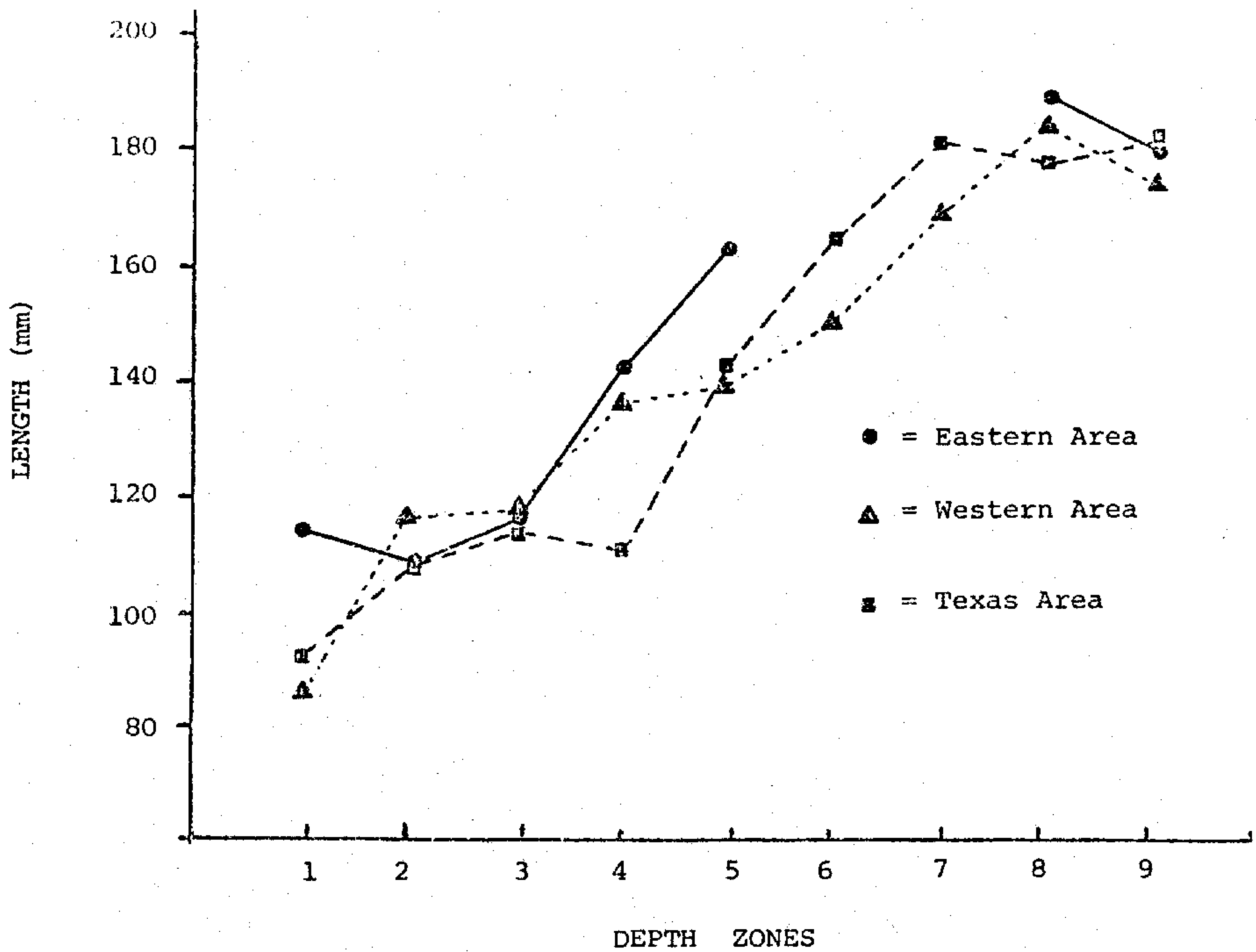

Figure 26. Mean total lengths for brown shrimp collected from the nine 5-fathom depth zones in each of the three major sampling areas studied during the 1982 closure. Means were calculated from $\log_{10}$-transformed measurements.

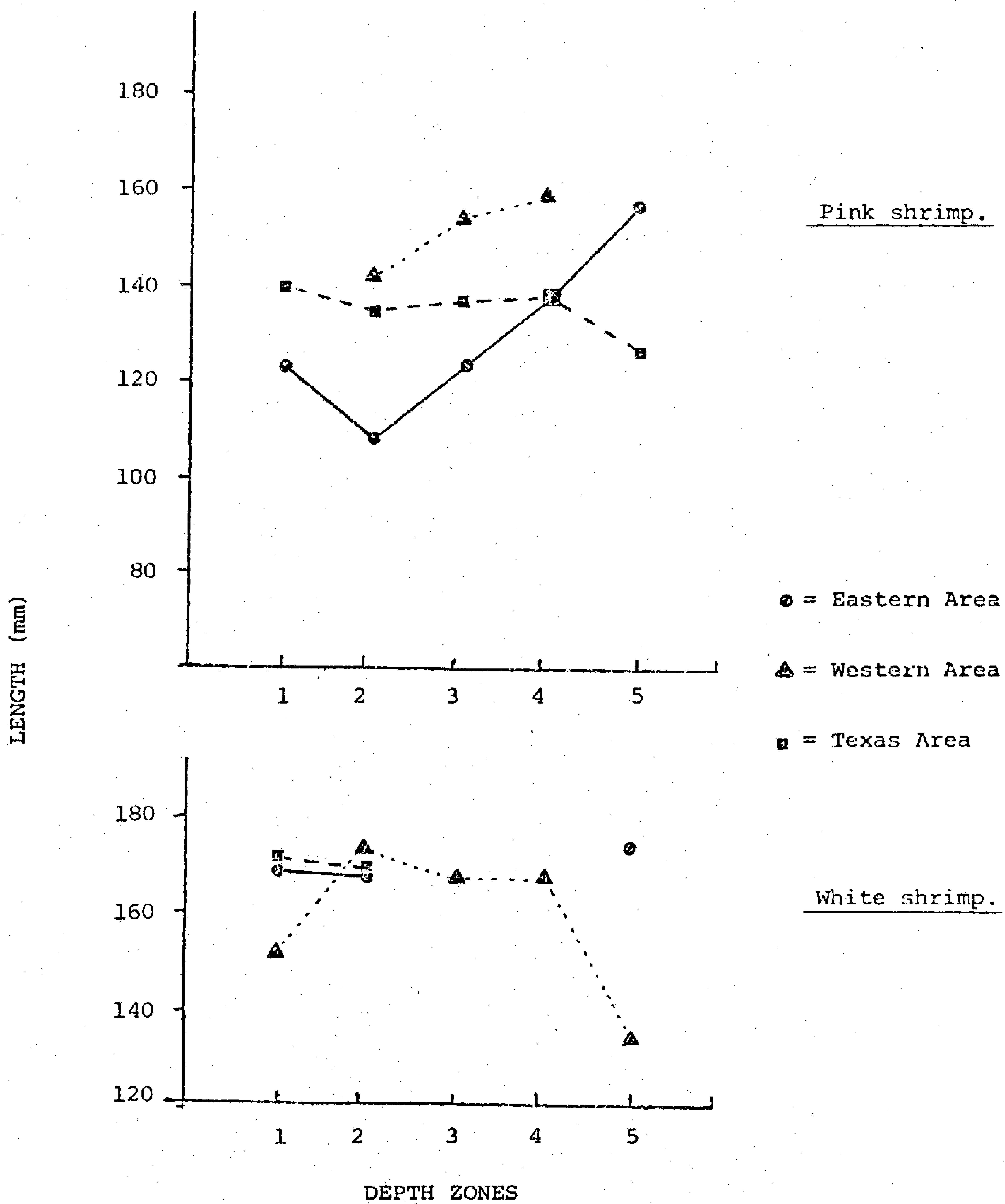

Figure 27. Mean total lengths for pink and white shrimp collected from five 5-fathom depth zones in each of the three major sampling areas studied during the 1982 closure. Means were calculated from $\log_{10}$-transformed measurements.